University of Southern Queensland

Faculty of Engineering and Surveying

Feasibility of Improved Traffic Flow on Cohoe Street, Toowoomba by Intersection Improvements

A dissertation submitted by

Miss Kelly Pearson

In fulfilment of the requirements of

Bachelor of Engineering (Civil)

November 2015

Abstract

Traffic congestion is an ongoing issue for most Australian cities. With Australia's growing population congestion issues will only further deteriorate, as this dissertation has found on Cohoe Street. Cohoe Street is section of the Warrego Highway making it a key part of the transportation network in Toowoomba, Queensland.

The three major intersections along the link, Tourist Road, Herries Street and James Street, were modelled in SIDRA Intersection using data provided by the Queensland Department of Transport and Main Roads. The results identified that Tourist Road and James Street both have movements that are at or nearing capacity. The sheer volume of through moving traffic on Cohoe Street was determined as the likely cause for the large delays for turning vehicles at James Street and Tourist Road.

Cohoe Street is a complex and challenging urban site due to the abutting land uses (residential and commercial), vehicle composition, traffic volumes and road classification. As such a number of potential solutions to improve the road link were identified including methods such as, access control and introducing traffic signals or roundabouts.

The options assessment identified the optimum solution as upgrading the existing signalised intersection of Mackenzie and James Street (the Warrego Highway) in combination with movement restrictions at Tourist Road and James Street.

The key benefits of implementing the recommendations outlined in this dissertation include the potential for improved safety, provision for enhanced cyclist and pedestrian facilities and improved intersection efficiency and flow along the link.

University of Southern Queensland
Faculty of Health, Engineering and Sciences
ENG4111/ENG4112 Research Project

Limitations of Use

The Council of the University of Southern Queensland, its Faculty of Health, Engineering and Sciences, and the staff of the University of Southern Queensland, do not accept any responsibility for the truth, accuracy or completeness of material contained within or associated with this dissertation.

Persons using all or any part of this material do so at their own risk, and not at the risk of the Council of the University of Southern Queensland, its Faculty of Health, Engineering and Sciences or the staff of the University of Southern Queensland.

This dissertation reports an educational exercise and has no purpose or validity beyond this exercise. The sole purpose of the course pair entitled “Research Project” is to contribute to the overall education within the student’s chosen degree program. This document, the associated hardware, software, drawings, and other material set out in the associated appendices should not be used for any other purpose: if they are so used, it is entirely at the risk of the user.

Candidates Certification

I certify that the ideas and experiential work, results, analysis and conclusions set out in this dissertation are entirely my own effort, except where otherwise acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where previously stated.

Kelly Pearson

Student Number: 0061002991

____

Signature

____

Date

Acknowledgements

I would like to acknowledge the following people for their contribution and assistance in this research project,

- Ron Ayers, for his guidance as my supervisor throughout this project.
- My colleagues and Managers at the Department of Transport and Main Roads, for their assistance with data collection and resourcing throughout this project.
- My family for their continued encouragement and support

Table of Contents

Abstract .... **I**

Candidates Certification .... **III**

Acknowledgements .... **IV**

Table of Contents .... **V**

List of Tables .... **X**

List of Appendices .... **XI**

List of Abbreviations .... **XII**

Chapter 1: Introduction **13**

1.1 Introduction 13

1.2 Background and Problem 14

1.3 Research Objectives 17

Chapter 2: Literature Review **18**

2.1 Introduction 18

2.2 Intersection Analysis 18

2.2.1 Level of Service 18

2.2.2 Capacity 20

2.2.3 Service Flow Rate 21

2.2.4 Degree of Saturation 22

2.3 Traffic Modelling Software 23

2.3.1 Analytical/Microscopic Modelling 23

2.3.2 Micro-simulation 24

2.3.3 Macro-simulation 24

2.3.4 Hybrid/Mesoscopic Simulation 24

2.4 SIDRA Intersection as a Modelling Tool 24

2.5 Methods for Improving Traffic Flow 27

2.5.1 Traffic Congestion 27

2.5.2 Intersections Traffic Control Devices 29

2.5.3 Movement Restriction..30

2.5.4 One Way Flow..30

2.5.5 Enforcement..32

2.5.6 Building New Infrastructure..32

2.5.7 Access Control and Management..33

2.5.8 Street widening..33

2.5.9 Grade separation..34

2.5.10 Managing Transportation Demand..34

2.5.11 Growth management..34

2.5.12 Alternate work hours..35

2.5.13 Site design to minimize traffic..35

Chapter 3: Dissertation Methodology..37

3.1 Data Collection..37

3.1.1 Traffic counts, AADT, Heavy Vehicle Percentage and Crash History37

3.1.2 Video Data..38

3.2 Model Development..38

3.2.1 Assumptions..39

3.3 Methodology Flow Chart..40

Chapter 4: Tourist Road Model Development and Results Analysis.........41

4.1 Geometric Properties of Site 1..41

4.2 Traffic Data..43

4.3 Crash History..44

4.4 Model Development..44

4.5 Results..44

4.6 Validation..47

Chapter 5: Herries Street Model Development and Results Analysis........49

5.1 Current Geometric Properties Site 2..49

5.2 Traffic data..52

5.3 Crash History..53
5.4 Model Development..54
5.5 Results..55
Chapter 6: James Street Model development and Results Analysis..........58
6.1 Intersection Layout 58
6.2 Traffic data...60
6.3 Crash History..61
6.4 Model Development...63
6.5 Results..63
6.6 Validation...66
Chapter 7: Options Investigation..67
7.1 Alternate Options...68
7.2 Options Selected for Comparison..69
7.2.1 Option A 69
7.2.2 Option A Estimate...73
7.2.3 Option B 73
7.2.4 Option B Estimate...77
7.2.5 Option C 78
7.2.6 Option C Estimate 82
7.3 Options Assessment...83
7.4 Recommendation...85
Chapter 8: Recommendations and Conclusion 86
8.1 Conclusion...86
8.2 Recommendations and Further Work 87
Chapter 9: References...89
Appendix A- Project Specification 91
Appendix B- Traffic Counts...93
B.1 Cohoe Street Flow Diagram (12 hours volumes).....................................94

B.2 Tourist Road- 12 Hour Totals 95

B.3 Herries Street- 12 Hour Totals 97

B.4 James Street- 12 Hour Totals 99

Appendix C- SIDRA Layouts 101

C.1 Tourist Road 102

C.2 Herries Street- Current Layout 102

C.3 Herries Street- Planned Layout 103

C.4 James Street 103

Appendix D- SIDRA Output Summaries 104

D.1 Tourist Road- Current Year (2015), no Bunching 105

D.2 Tourist Road- Current Year (2015), 20 % Bunching, Stage 1 106

D.3 Tourist Road- 10 Year Design Period, 20% Bunching 107

D.4 Tourist Road- 20 Year Design Period, 20% Bunching 108

D.5 Herries Street- Current Layout (2015) 109

D.6 Herries Street- Signalised Layout, 0 Year Design Period 109

D.7 Herries Street- Signalised layout, 10 Year Design Period 110

D.8 Herries Street- Signalised Layout, 20 Year Design Period 110

D.9 James Street- Current Year (2015) 111

D.10 James Street- 10 Year Design Period 112

D.11 James Street- 20 year design period 113

D.8 James Street- Options Investigation (signalisation) 114

Appendix E- Chartview Data 115

Appendix F- Herries Street DTMR Intersection Report 118

List of Figures

Figure 1: Level of Service (Austroads Guide to Traffic Management, 2013).....13
Figure 2: Cohoe Street Toowoomba, Southern Direction (K. Pearson) 15
Figure 3: Cohoe Street, Toowoomba (K. Pearson & DTMR) 16
Figure 4: Level of Service and Service Flow Rates (Austroads Guide to Traffic Management, 2013)..22
Figure 5: Aerial Photo, Intersection of Tourist Road and Cohoe Street (DTMR) 41
Figure 6: Photograph, Intersection of Tourist Road and Cohoe Street (K. Pearson) 41
Figure 7: Site 1 Movement Definitions (K. Pearson) 42
Figure 8: Aerial Photo, Intersection of Herries Street and Cohoe Street (DTMR) 49
Figure 9: Photograph, Intersection of Herries Street and Cohoe Street (K.Pearson)...49
Figure 10: Site 2 Movement Definitions (K. Pearson) 51
Figure 11: Aerial photo, Intersection of James Street and Cohoe Street (DTMR) 58
Figure 12: Photograph, Intersection of James Street and Cohoe Street (K. Pearson) 58
Figure 13: Site 3 Movement Definitions (K. Pearson) 59
Figure 14: Possible Alternative Routes for Restricted Access at James Street & Right Turn Diversion from Tourist Road to Herries Street (Option A) (Google Maps, 2015)...71
Figure 15: Alternative Route for Accessing James Street & Diverted Right Turn from Tourist Road to Herries Street (Option B) (Google Maps, 2015). 76
Figure 16: Alternative Routes via Herries Street (Option C) (Google Maps, 2015)..81

List of Tables

Table 1: Performance Measures Used for Defining Levels of Service (Austroads 2007) 20
Table 2: Key Geometric features of Tourist Road and Cohoe Street Intersection 43
Table 3: Tourist Road Peak Hour Summary (QDTMR) 43
Table 4: Crash History Site 1 44
Table 5: Movement Summary Tourist Road, Scenario 1 45
Table 6: Movement Summary Tourist Road, 0, 10 and 20 year design period 46
Table 7: Level of Service Summary, Site 1 47
Table 8: Key Geometric Features Site 2 51
Table 9: Site 2 Peak Hour Summary 52
Table 10: Site 2 PM Peak Hour Summary with Development Contributions 52
Table 11: Crash History Site 2 (DTMR) 53
Table 12: Movement Summary Site 2, Current Year, 2015 (without development) 55
Table 13: Movement Summary Site 2, 0, 10 and 20 Year Design Period (with signalisation) 57
Table 14: Key Geometric Features Site 3 60
Table 15: James Street Peak Hour Summary 60
Table 16: Crash History Site 2 (DTMR) 61
Table 17: Movement Summary Site 3, 0, 10 and 20 year design period 64
Table 18: Level of Service Summary, Site 3 65
Table 19: Option A Summary 69
Table 20: Option A Estimate 73
Table 21: Option B Summary 74
Table 22: Option B Estimate 78
Table 23: Option C Summary 79
Table 24: Option C Estimate 82
Table 25: Options Assesment 83
Table 26: Options Assessment Marking Scheme 83
Table 27: Options Key Advantages and Disadvantages 84

List of Appendices

Appendix A: Project Specification

Appendix B: Traffic Counts

Appendix C: SIDRA Layouts

Appendix D: SIDRA Output Summaries

Appendix E: Chartview Data

Appendix F: Herries Street DTMR Intersection Report

List of Abbreviations

AADT - Annual Average Daily Traffic

DTMR – Department of Transport and Main Roads

DVR – Digital Video Road

HV - Heavy Vehicles

MUTCD – Manual of Uniform Traffic Devices

RPDM – Road Planning and Design Manual

TARS- Traffic Analysis and Reporting System

PCR- Passenger car equivalent

LOS- Level of service

VCR- vehicle-to-capacity ratio

HCM- Highway Capacity Manual

Vpd- Vehicles per day

CHR- Channelised Right Turn Treatment

Chapter 1: Introduction

1.1 Introduction

Traffic congestion is one of the key critical transportation concerns facing Australia. Traffic congestion has many impacts on the community additional to the impedance of mobility and connectivity such as the contribution to air pollution, excess fuel consumption and hindering economic growth.

Traffic congestion occurs when the demand on the road network is greater than the facilities capacity to operate with acceptable levels of delay. Level of service is the term used to classify the operating capacity of a road link or intersection. It is defined by a graded scale from A to F, with A representing optimal free flow conditions and F being heavily congested. Level of Service can be linked directly to the ratio of average passenger car speed to traffic volume. Austroads details this relationship in figure 1 below.

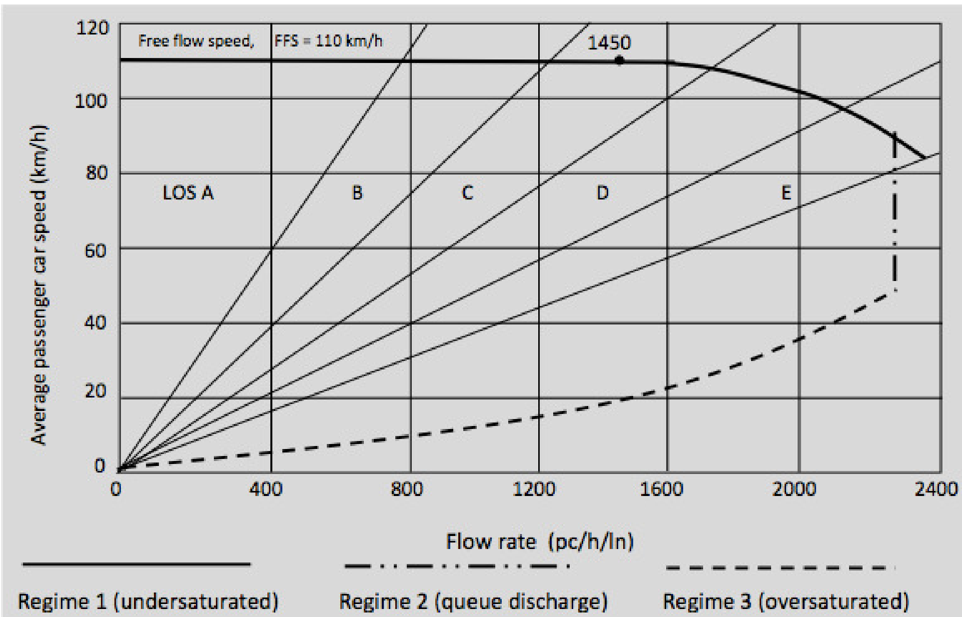


Figure 1: Level of Service (Austroads Guide to Traffic Management, 2013)

As the number of vehicles using a facility increases, the mean speed tends to decrease, resulting in a reduced level of service for the intersection or road link. Traffic composition also contributes to the flow rate of a link, specifically the volume of heavy vehicles due to their differing operational characteristics. Heavy vehicles are restricted in their ability to gain momentum if slowed or stopped, have reduced manoeuvrability and occupy a larger space within the road corridor than passenger cars.

Road transportation is the predominant choice for most Australians and as such there is a level of expectation from the community regarding the safety and efficiency of the network. It is the responsibility of the road authorities to manage, maintain and improve the network to ensure the infrastructure is performing to its full potential and providing a level of service that meets those needs and expectations of the community.

The following dissertation aims to investigate the operational characteristics of Cohoe Street, Toowoomba. Cohoe Street was selected for investigation due to the complex nature of the link, as detailed in section 1.2.

SIDRA Intersection will be used with data and resources being provided by the Department of Transport and Main Roads.

1.2 Background and Problem

Toowoomba city is located approximately 130 kilometres west of Brisbane with the Warrego Highway linking the two. The Warrego Highway is one of the main Heavy Vehicle route that runs directly through Toowoomba and continues on to the Western Downs.

The Western Downs Region encompasses the Town of Dalby and the Shires of Chinchilla, Murilla, Tara, Wambo and division two of the Shire of Taroom. The region is continuing to develop with industry such as farming and mining continuing to place greater demand on the Highway.

Cohoe Street is a section of the Warrego Highway that provides the entry point to Toowoomba. It runs from the intersection of Tourist Road to the intersection of James Street with an approximate North- South orientation. Along the 700 metre link there are a variety of businesses including motels, a service station, and a shopping centre along with residential properties including houses and unit blocks.

Figure 2: Cohoe Street Toowoomba, Southern Direction (K. Pearson)

The three major Intersections, Tourist Road, Herries Street and James Street will be analysed with the smaller side streets not being considered due to their impact on the functionality of Cohoe Street being assumed as negligible.

The current configuration of the through road is two lanes in each direction with a sixty kilometre per hour speed limit. The adjoining minor roads are currently sign controlled, although there is a commercial development on the North-West corner of Herries Street that is due for completion in 2016 that plans to introduce traffic signals at the intersection.

There has been one fatal crash at the Herries Street intersection in 1994 and numerous minor crashes involving property damage on record from 1993 to 2011. James Street intersection also has an extensive history of crashes, none have been fatal. The focus of the dissertation is on the functionality of the road link and as such the safety of the intersections has not been investigated explicitly.

The second range crossing is a bypass for Toowoomba that has been in the planning stages for many years. The aim of the project is to divert the large number of heavy vehicles and passing traffic that currently have to travel directly through the city’s centre. This year the project received funding and is currently in the early stages of resourcing. Due to the large scale of the project the planned opening date is unclear and as such the implications of the project have not been considered for this dissertation. The relief that the bypass will provide for Cohoe

Street when completed is likely to only to be temporary as traffic will initially reduce but then continue to grow.

Figure 3 provides an aerial photo of the Cohoe Street link with the adjoining streets highlighted.

Figure 3: Cohoe Street, Toowoomba (K. Pearson & DTMR)

1.3 Research Objectives

The following is the defined scope of this analysis of Cohoe Street.

1. Research background information, from both Australia and Overseas, regarding; intersection modelling, Level of Service standards for intersections and methods for improving over capacity intersections.
2. Gather the required traffic data (counts and growth projections) for the selected intersections and any other relevant planning proposals that may impact on the functionality of Cohoe Street. Draft basic layouts of the intersections and the arterial road. Calculate traffic data for future cases using traffic growth projection.
3. Develop a model in SIDRA Intersection containing all of the intersections so they can be analysed individually and potentially as a network if required. Adopt standard SIDRA parameters for first pass of analysis.
4. Validate the model by comparing outputs of average delay and gap acceptance with data collected from video footage of the intersections and calibrate if necessary.
5. Use the model to predict traffic flows and performance of Cohoe Street under future predicted traffic flows, and consider strategies to optimise flows.
6. Depending on the outcome of the analysis, re-model in SIDRA to develop upgraded layouts for intersections, optimising network cohesion and efficiency.

The methodology in Chapter 3 describes how these objectives are achieved.

Chapter 2: Literature Review

2.1 Introduction

The main objectives of the research is to gain a deeper understanding of the fundamentals of intersection modelling, validation of the use of SIDRA Intersection as a reputable software package, the safety and functionality of the different types of intersections focusing on signalised and sign controlled as well as different vehicle types and their operational characteristics.

2.2 Intersection Analysis

Intersection analysis is a complex process that is fundamental to transport planning. The core concepts researched are Level of Service, Capacity, Degree of Saturation and Service Flow Rate as these are deemed highest priority concepts for network functionality.

2.2.1 Level of Service

Level of service is at the core of network analysis and is essentially the fundamental grading scheme by which conclusions are made about the operational functionality of a network or individual intersection. Understanding the concept of level of service and how to employ it is a requirement for confidence in one's ability to assess the functional lifespan of a road link.

The Highway Capacity Manual describes Level as Service (LOS) as "a quantitative stratification of a performance measure or measures that represent quality of service" (TRB, 2010). This is consistent with Austroads (an Australian and New Zealand Road Transport and Traffic Authority) definition of Level of service as being "a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passengers" (Austroads, 2007). The Department of Transport of Main Roads (DTMR) accepts these definitions and uses Level of Service to determine the lifespan of an intersection.

LOS has six levels of service from A to F as defined by (TRB, 2010). LOS A identifies the ideal operating conditions as seen from the traveller's perspective with LOS F representing the worst. The system of an A to F scale is designed to aid in simplifying the decision around a facility's operational performance. Although LOS A represents the optimal case scenario facilities are typically not designed to achieve it due to prohibitive costs, environmental impacts and other reasoning (TRB, 2010). Acceptance of LOS is situational as one authority may accept a LOS D but to another authority or at another site this may be considered unacceptable.

It should be noted that an urban facility is described as a section of roadway that incorporates urban street segments and can generally be defined as an urban arterial (TRB, 2010). To be considered an urban arterial there must be at least one facility along the link that requires a possible stop or yield on the through movement (TRB, 2010). This requirement for Cohoe Street will be met with the inclusion of the development at Herries Street and as such it shall be considered as an urban arterial for the purpose of analysis.

The LOS standards and control measures differ between sign controlled and signalised intersections. The difference is due to the variance in driver expectations between functionality of traffic signals and sign controls. Traffic signals give the road users the perception that the link has a higher traffic volume hence the requirement of signals, which brings an expectation and acceptance of longer average delays. In comparison sign controlled intersections don't have the same degree of predictability as signals. This can decrease the road users' acceptance of delay times at sign controlled sites (TRB, 2010).

Austroads adapted information outlined in the Highway Capacity Manual to develop a table outlining the performance measures used for defining levels of service. The table highlights the principal control measure for varying types of intersections.

Table 1: Performance Measures Used for Defining Levels of Service (Austroads 2007)

Element	Level of service measure[1]	Performance measure used
Vehicular		
Interrupted flow		
▪ Urban street	speed	speed
▪ Signalised intersection	delay	delay
▪ Two-way-stop intersection	delay	delay
▪ Roundabout	delay	delay
▪ Interchange ramp terminal	delay	delay
Uninterrupted flow		
▪ Two-lane highway	speed, per cent time spent following	speed
▪ Multi-lane highway	density	speed
▪ Freeway		
– Basic segment	density	speed
– Ramp merge or diverge	density	speed
– Weaving	density	speed
Other road users		
Public transport	[2]	speed
Pedestrians	space, delay	speed, delay
Cyclists	event, delay	speed, delay

1 Service measure for a given facility is the primary performance measure and determines the level of service.
2 Several measures capture the multidimensional nature of transit performance when defining level of service (HCM 2010, Chapter 11).

2.2.2 Capacity

Capacity is a fundamental concept in traffic analysis therefore research into the implications and role it has pertaining to network operations was imperative to confidently undertake a link analysis.

The Highway Capacity Manual provides two definitions for capacity one pertaining to system elements and one for vehicles capacity as follows,

"The *capacity* of a system element is the maximum sustainable hourly flow rate at which persons or vehicles reasonably can be expected to traverse a point or a uniform section of a lane or roadway during a given time period under prevailing roadway, environmental, traffic, and control conditions" (TRB, 2010).

"Vehicle capacity is the maximum number of vehicles that can pass a given point during a specified period under prevailing roadway, traffic, and control conditions. This assumes that there is no influence from downstream traffic operation, such as queues backing into the analysis point" (TRB, 2010).

Austroads employs the above definitions and refers to them in the Guide to Traffic Management which is a main resource utilized by DTMR.

Numerous factors contribute to the capacity of a network or facility such as traffic volumes and vehicle type, control conditions and the geometric properties (roadway conditions). The conditions of a network should be fairly consistent when analysed as alterations in prevailing conditions impacts a segments capacity (TRB, 2010).

The geometric elements of a network element can influence capacity in some instances whereas in others it may be impacting on driver perception and speed. Drive perception and speed are performance measures rather than flow rate or capacity. Roadway conditions incorporate the following lane number and widths, alignments both vertical and horizontal and lane configurations at intersections (TRB, 2010).

Introducing heavy vehicles onto a roadway can impact on the capacity of the network. Heavy Vehicles are considered to be vehicles that have more than four wheels such as B-Double and Road Trains. Heavy vehicles have limitations around their operational performance in respect to acceleration, deceleration and maintaining speed on steep grades especially when compared to passenger cars. The size of a road train for example is 36m whilst an average passenger car is around 2.5m. This difference means that the Heavy Vehicles are physically occupying more of the roadway, reducing the capacity (TRB, 2010). These issues surrounding Heavy Vehicles are hard to overcome especially when amplified in certain situations. Steep downgrades where trucks must employ lower gears/speeds and on steep upgrades where the differential speed between trucks and cars is large creates inefficiencies in the roadway with gaps created being difficult to occupy (TRB, 2010).

The traffic flow distribution across the lanes of a roadway network can also have implications on capacity with directional flows sometimes being linked to the AM peak or the PM peak. For two lane rural highways it is directional distribution that has the most implications with the ideal scenario being an even distribution across the directions of travel (TRB, 2010).

2.2.3 Service Flow Rate

Service flow rate is the suggested maximum hourly rate for which a person or vehicle can fairly traverse a point whilst retaining a designated level of service. Service flow rate is directly linked to level service although it used discrete values rather than a range. There is a service flow rate value for each level of service, which is typically calculated over a fifteen-minute period of time and indicates the pedestrian or vehicle capacity for that level of service. A level of service relating to actual traffic volumes is determined using the calculated service flow rate (Austroads, 2013). Figure 4 is from the Austroads Guide to Traffic Management and shows the relationship of Levels of Service and service flow rates for a free speed of 110km/hr. This is called an operation curve.

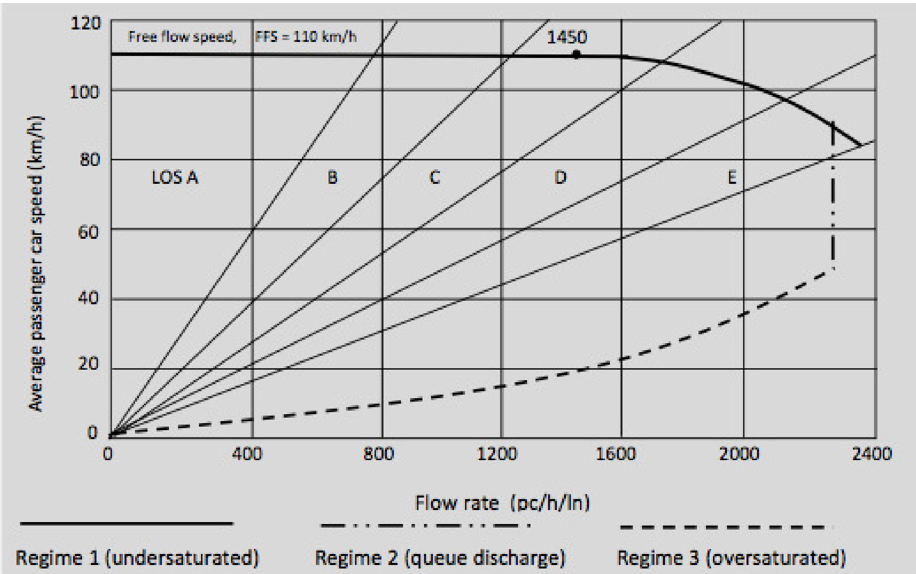


Figure 4: Level of Service and Service Flow Rates (Austroads Guide to Traffic Management, 2013)

2.2.4 Degree of Saturation

Degree of Saturation for the approach to a signalised intersection can be described as the ratio of capacity to the arrival demand flow. It is a discrete numerical value with up to one representing at capacity or saturated flow and above indicating oversaturated approach with queuing occurring. Volume to capacity ratio (VCR) is another term used to describe degree of saturation. Typically degrees of saturation in the lower end of the range represent higher quality of facility. 0.9 is considered the target volume to capacity ratio for signals and 0.80 for sign controlled. These values are often referred to as 'practical degrees of saturation' (Austroads, 2013).

The roadway conditions, terrain conditions, traffic volume and types directly affect degree of saturation much like LOS and Capacity. Terrain relating to roadways can be defined in three ways; level, rolling and mountainous. Level terrain describes a geometric alignment that enables heavy vehicles to operate similarly to passenger cars with speed. Rolling terrain describes a geometric alignment that for heavy vehicles a significant decrease in speed to that of passenger cars is required to navigate the network. A crawl speed is not accepted for extended periods of time. Mountainous terrain is a geometric alignment that restricts heavy vehicles to a crawl speed for extended distances or at recurring intervals (Austroads, 2013). Roadway conditions are inclusive of the design speed, lane widths, vertical and horizontal alignment and facility type i.e. signalised or sign controlled (Austroads, 2013).

2.3 Traffic Modelling Software

Intersection modelling and analysis can be a complex or simple task depending on the specifics of the site being investigated. Signalised intersections particularly are more complex with issues relating to signal phasing and pedestrian requirements. Manual calculations are possible but with technology consistently improving there is a visible move towards computer modelling for traffic analysis.

There are predominantly four types of software based traffic modelling; analytical/microscopic modelling, microscopic simulation, macroscopic simulation and hybrid/mesoscopic simulation. Each package uses traffic volumes and growth, vehicle types and road geometry to give an indication of how the intersection is operating.

The selection of software is situational with time, resources, project scope and budget all requiring consideration.

2.3.1 Analytical/Microscopic Modelling

The Austroads Research Report *The use and application of microsimulation traffic models* describes analytical modelling as a technique that directly relates to traffic flow theory, often being a group of equations governing driver behaviour characteristics such as changing lanes, gap acceptance or platooning. Some examples of the many available micro model software packages are as follows;

- SIDRA Intersection
- SCATES
- ARCADY

- OSCADY

2.3.2 Micro-simulation

Micro-simulation tracks the movement of individual vehicles through a network using a sub-second time increment. The programing utilises random number generators making model calibration intensive (James Luk and Johann Tay, 2006). The outputs are given as both a text file and a visual animation. Example software packages are as follows;

- AIMSUN
- VISSIM
- QuadstoneParamics
- CORSIM

2.3.3 Macro-simulation

Macro-simulation tracks the movement of vehicles as grouped traffic streams rather than individual entities. The time step over which platoons are tracked is one or more seconds (James Luk and Johann Tay, 2006). Traffic signal optimisation is an ideal task for macro-simulation. The following are example software packages;

- VISUM
- CUBE Suite
- TRANSYT
- CONTRAM

2.3.4 Hybrid/Mesoscopic Simulation

Hybrid Simulation encompasses an in-depth microscopic simulation of some core components of a model with analytical models for example intersection operations and speed flow relationships (James Luk and Johann Tay, 2006). Example software packages are as follows;

- TransModeler
- Aimsun

2.4 SIDRA Intersection as a Modelling Tool

SIDRA Intersection is one such Micro Model packaged and is the choice for DTMR due to its simplicity. DTMR holds networking licensing for SIDRA

Intersection and therefore it was selected as the tool for undertaking the analysis of Cohoe Street. The following section reviews a case study that also validates the use of SIDRA along with the SIDRA User Guide.

Austroads continues to support research in the field of road design, traffic management and transport planning. Project number NS1371 "Modelling of Signalised Intersections: Case Study" was published in 2010 (publication number AP-R365/10) and prepared by Ian Espada, Paul Bennett and James Luk with Young Yoo acting as Project Manager.

The project investigated options available for modelling signalised intersections with the aim of providing guidance for technical persons on selecting the appropriate modelling techniques (Austroads, 2010). The researchers based the project around a case study, choosing two sites of varying complexity to model in different software packages. The outcomes compared were not only the results of the models but also the resourcing required to develop the model and the need for specialist capability to develop the model.

When modelling a signalised intersection the main programs used in industry are either micro-modelling software such as SIDRA Intersection or micro simulation with VISSIM, Q-PARAMICS and AIMSUN being the most commonly used by road/transport authorities within Australia. Both have advantages and disadvantages with the main difference being that micro simulation uses a visual simulation of the road network functioning in comparison to Micro modelling which is developed from traffic flow theory (Austroads, 2010).

The report found that when comparing the outputs of SIDRA with that of fixed-time micro simulation models they were equally accurate when approximating maximum and mean back of queue for the study site, which was under saturated conditions. SIDRA outputs were also comparable to field measurements of cycle average queue (Austroads, 2010).

When comparing SIDRA with VA and SCATSIM both of which are complex micro simulation software packages the outputs of SIDRA for queue length approximations were found to be less accurate under certain conditions. Comparatively for fixed time models the output accuracy for the different packages was varied therefore it was found that there wasn't an evident advantage in choosing to use either micro simulation or SIDRA when referring to model accuracy alone (Austroads, 2010).

Although the outputs of the micro simulation models were thought to be more accurate, practicalities around their use were also highlighted. SIDRA is fairly simplified software in that only basic training is required to be able to develop a model and utilise its capabilities. Comparatively micro simulation modelling requires significantly larger resourcing requirements in the range of 20% and higher labour demand. Micro simulation though has the ability to encompass greatly variable phase sequences and visual simulations but these do require a greater level of training to correctly input the data and manipulate the software (Austroads, 2010).

Austroads (2010, commented that is has been identified by road and transport authorities that the use of SIDRA is occasionally over extended along with the over-use of micro simulation packages resulting in uneconomical resource use highlighting the importance of the research being done.

With the aim of the project being to simplify the selection of modelling techniques a recommended hierarchy of modelling techniques was formed from the conclusions of the case study. The hierarchy suggests manual calculations, micro-modelling using packages such as SIDRA and then micro simulation. The idea is that the least costly option should be taken first and then if the need arise move to a more complex modelling system. This would see the best use of resources and time meaning more efficient and cost effective practice for businesses (Austroads, 2010).

Selection of the correct software and process has been proven to have great implications on the overall cost of a project and not just for the initial analysis of the intersections. Examples of when overdesign can occur is in the determination of merge and queue lengths. The additional length adds unnecessary construction costs. Under design is also a possibility with the implications being greater than just cost, as substandard design can lead to driver frustration. Examples of under design include queue lengths and signal phasing with the worst case scenario resulting in a decrease in the safety of the facility. It is imperative that sufficient resources are allocated to the intersection and options analysis phase of a project including specifically the software selection although caution around over analysis needs to be taken as well (Austroads, 2010).

The case study also brought to light some of the limitations of the software used in the area of environmental concern. Both the micro simulation and micro model software outputs were lacking accuracy in their estimations of environmental factors. As a recommendation more emphasis needs to be placed on investigating and potentially modelling the impacts of a road network on the environment (Austroads, 2010).

Overall the project has demonstrated the importance of selecting the correct technique when modelling signalised intersection. SIDRA Intersection was second place on the recommended hierarchy for technique selection, validating its position as a comprehensive and cost effective software packages.

2.5 Methods for Improving Traffic Flow

One of the key objectives of this project is to provide feasible recommendations on how to improve the traffic flow on Cohoe Street, Toowoomba. A Toolbox for Alleviating Traffic Congestion is a document prepared by the Institute of Transportation Engineers, America that details a multitude of ways to improve congestion. The Toolbox was published in 1989 but still proves relevant to today.

The following section will review some of the key segments from the report and establish a correlation with the Australian Austroads Design Guides. The impacts of congestion along mitigating treatments will be discussed, as finding a solution begins with the big picture of understanding the implications that traffic congestion has on a community.

2.5.1 Traffic Congestion

Traffic congestion is one of the main critical transportation issues facing most developed countries around the world. Congestion impacts on the community in a multitude of ways including, impeding mobility, hindering economic growth, contributing to excess fuel consumption and air pollution. It is important to recognise that traffic congestion is a more complex issue than simply too many vehicles. There are land use and institutional levels to the problem that contribute to the complexity (ITE, 1989).

Traffic congestion occurs when the demand on the road network is greater than the facilities capacity to operate with accepted levels of delay (ITE, 1989). Some of the consequences that congestion can have for a community are described by the Institute of Engineers as follows;

Local Impacts- Drivers will often look for alternate routes to avoid congestion, often this is through local streets in residential areas. The streets have not been designed to cater for the increase in traffic resulting in neighbourhood complaints (ITE, 1989)

Economic Growth- Effective transportation access to development sites and employment is a key consideration when considering project opportunities. Residents will look for good transportation systems within suburbs when relocating making it a significant selling point. Good transportation is also fundamental to the movement of goods and services therefore directly influencing economic growth (ITE, 1989)

Community Access- Community access is not only important for residents when looking for areas to live but it’s also imperative for public safety (fire, ambulance, police) (ITE, 1989).

Quality of life- The view of some people is that congested road links are a reflection of deterioration in quality of life. This may seem extreme but for some people the choice to relocate is to avoid urban issues like traffic congestion (ITE, 1989).

Traffic crashes tend to become more prevalent in congestion whether it is navigating intersections or stop go traffic on main arterials. Minimizing the congestion has the potential to improve safety (ITE, 1989).

Environmental Impact- Air quality is heavily impacted by traffic congestion. If changes can be made to travel behaviour or improvements to the traffic system the severity could be reduced (ITE, 1989).

The impacts outlined above highlight the importance of identifying and mitigating traffic congestion. There are numerous ways this can be done outside of building new capacity or expanding upon existing infrastructure such as managing the transportation system and demand (ITE, 1989).

Adapting existing infrastructure to create capacity is typically the cheapest to implement. It may include techniques such as implementing traffic control devices, restricting turn movements or converting two way flow to one all of which require the overarching tool of enforcement.

2.5.2 Intersections Traffic Control Devices

Intersection traffic control devices are useful for improving the flow of vehicles and pedestrian safety. Devices include signage (stop, give way), traffic islands, turning lanes, channelization and enhanced design. Substantial benefits are gained with the separation of traffic and generally enhanced safety operation.

The associated costs involved with the planning and implementation of this technique is modest but can vary substantially depending on the number installed and the site complexity. As such, defining the real costs and benefits is difficult (ITE, 1989).

The Institute of Transport Engineers outlines eleven principles to consider when designing and improving at grade arterial intersections, they are as follows;

1. Decrease the number of conflict points
2. Control the approach and departure speeds of vehicles
3. Coordinate traffic control devices with traffic volumes
4. Select intersection type to best serve the volume of traffic
5. With large volumes consider separation of turn movements
6. Minimize driver decisions by avoiding multiple or compound merging and diverging manoeuvres.
7. Disperse conflict points
8. The heaviest and quickest flows should be prioritized
9. Decrease conflict area
10. Isolate non-homogenous flows i.e. turn lanes
11. Give consideration to cyclists and pedestrians

These techniques align with the Austroads Guide to Traffic Management Part 6- Intersections, Interchanges and Crossings where they suggest that regulatory signs and/or physical devices such as channelization are possible treatments for reducing volumes at intersections. Providing turn bays and reviewing signage are also detailed as possible treatments for improved operational efficiency (Austroads, 2013).

2.5.3 Movement Restriction

Prohibiting or restricting turn movements is a way of eliminating conflict points, improving safety and reducing congestion. Turn prohibitions are not always necessary for all times of the day, rather they can be kept to peak hours or times where there are known issues. Adequate signage needs to be clearly visible to motorists with increased enforcement likely required at the early stages of implementation. Restricting turn movements to certain phases at signalised intersections is common practice and most effective when separate turn lanes are provided.

The cost/benefit of restricting turn movements is difficult to quantify as it causes a change in travel route. The ITE (1989) states that in San Francisco data compiled showed that crashes were reduced from 52% to 38% across the four intersections studied. Each of the intersections carried high volumes with 30,000 to 50,000 vehicles per day (ITE, 1989).

Designated turn lanes are an alternative to prohibiting turns but they require additional width. Restricting parking, if available, is a way of obtaining the required width but the implications of reduced parking need to be fully examined.

The ITE (1989) recommends that the following six points be examined when considering prohibiting turns.

1. The degree of delay and congestions caused by the turning movements
2. The number of crashes resulting from the turn movements
3. Availability of alternate routes
4. Potential impacts of diverting the flow to other intersections
5. Possible environmental impacts resulting from diverted traffic flow
6. Feasibility of alternate solutions i.e. provision of turn lanes

2.5.4 One Way Flow

Converting existing two way flow to one way can be of benefit in certain situations although great consideration needs to be given to impact on travel routes and access.

One-way streets typically operate in one of three ways

1. Traffic flows in one direction all of the time

2. Traffic typically flows in one direction but at certain times is reversed to provide additional capacity
3. Traffic flows in both directions but during peak hour flow is restricted to one way. The restricted flow direction can alternate depending on the peak (ITS).

The Austroads Guide to Traffic Management Part 5- Road Management (2013) quotes the ITE (1989) for the disadvantages and advantages of one way movements but in regards to the above operational characteristics of one way flow the recommendations differ. Part 5 of the Guide to Traffic Management (2013) encourages one way flow to be in the same direction at all times with reversible flow only being used rarely.

One way links provide increased capacity through reduction in intersection delays with reduced turn conflicts, reduction to travel time, allowing turns from multiple lanes and re-distributing traffic flows. Increased safety is also a positive outcome with the reduction of conflict points for vehicles and pedestrians (ITE, 1989).

The Austroads Guide to Traffic Management Part 5- Road Management (2013) states that increases in capacity ranging from 20 to 50% over two-way operation have been recounted. Along with reductions to total crash occurrences ranging from 10 to 50% and decreases in travel time of 10 to 50%.

The ITE (1989) recommends as a general rule that two-way streets should only be converted to one-way when;

1. It's demonstrated that a specific traffic issue will be alleviated or the overall efficiency will be improved
2. It is more cost-effective and desirable than alternative options
3. Parallel streets with acceptable capacity are readily available or can be constructed
4. Safe transition back to two-way flow can be provided
5. Transit service is maintainable
6. The street will align with the master plan and be compatible with adjoining land uses.

2.5.5 Enforcement

Each of the techniques identified above require strict enforcement to achieve the desired outcome. Changing individual behavior is a process that happens over time requiring education and clarification of the changes. There are actions that form an integral part of each of the programs outlined above.

1. Education- sufficient time must be allocated to informing the public of any changes and the expected benefits associated with the change.
2. Clarity in the explanation and description of the proposed programs.
3. Increase in the number of enforcement staff in the initial stages of implementation.
4. Sensible fines for failing to comply with regulations (ITE, 1989).

Increased enforcement could come at substantial cost and as such needs to be accounted for in the overall program budget. The benefits however should be substantial.

Austroads does not appear to make mention of the enforcement requirements for recommended treatment options. Enforcement does form a part of the overarching approach to local area traffic management as highlighted by the ITS and as such should be considered when implementing/considering options that require change in drivers behavior.

2.5.6 Building New Infrastructure

Increasing capacity can also be done through building new infrastructure. New highways are one such form of new infrastructure they are typically considered in urban environments where congestion is often the greatest. The benefits stem from substantial reductions in traffic volumes on the existing road link as such reducing congestion. The success of a new road link is determined by its accessibility and ability to serve the locations that vehicles are destined for such as employment or shopping developments (ITE, 1989).

The Second Range Crossing is a new highway that is due for completion in 2018. It will essentially serve as a bypass for Toowoomba in an attempt to reduce the number of heavy vehicles traveling through the city center. As mentioned by the Institute of Engineers, the magnitude of the impact is reliant on the accessibility of the new road along with the ability to serve amenities. As such the impact of the bypass on Cohoe Street will be disregarded for this investigation, as the implications are not quantifiable.

2.5.7 Access Control and Management

The road hierarchy is a classification system for the road network based on the intended function of the road. The functional classification of highways is related to the level of accessibility and mobility (continuous free flowing travel). Access control and management refers to the enforcement and implementation of guidelines that define the way in which access will be provided to a highway. Highways have the primary function of providing mobility; this is maintained by allowing access at selected locations (ITE, 1989).

Correctly implemented access control can provide an increase in safety. Safety is known to decrease as the number of access points such as driveways and intersections increases along a highway or arterial road link. Traffic flow can also be maintained or improved through limiting access (ITE, 1989)

The Austroads Guide to Traffic Management Part 5- Road Management provides extensive detail regarding access management that coincides with the Institute for Traffic Engineers recommendations. The guide describes techniques for assisting with the provision of access management including intersection spacing and indented turn lanes. Increased distance between intersections typically improves the flow of traffic on arterial roads, which leads to reductions in traffic congestion and improvements to air quality. Auxiliary left and right turn lanes improve not only traffic flow but safety as well by removing the conflict between turning and through moving vehicles (Austroads, 2013)

2.5.8 Street widening

Street widening can be implemented in two ways. One being to widen the existing traffic lanes and the second option is to provide additional lanes. Driver perception and behaviour is effected by lane widths. Decrease in width can lead to a feeling of confinement resulting in reduced travelling speeds. Providing additional lanes physically increases the capacity of the road link. (ITE, 1989)

The cost of impending wider lane widths is site dependant. In some situations it may be a simple line marking exercise that reduces the width of the shoulder or it may require physical widening of the roadway. Generally introducing new traffic lanes requires moderate roadworks and in some instances land resumption although in the case of highways the ITE states that the addition of lanes to a highway can provide three to four times the benefit in comparison to costs.

Austroads details the typical road space requirements for general traffic use in the guide to traffic management along with a volume guideline for the provision of overtaking lanes. Overtaking lanes are a form of street widening that is commonly implemented on rural highways. It is also common practice within industry to use street widening as a method for improving the capacity of road links in the urban environment.

2.5.9 Grade separation

Grade separation refers to the physical separation of differing traffic flows such as bridges (overpasses). Grade separation can be applied to vehicular traffic and pedestrians to ease congestions and also improve safety. Grade separated pedestrian facilities are common in the urban environment where there is generally increased concentrations of pedestrians.

Grade separation will always provide an increase in capacity although the costs to implement are often significant due to the disturbance to traffic and business during the construction period, right-of-way requirements and construction costs. The Institute of Traffic Engineers suggests that an alternative option to the established grade separated structure is a flyover. The disruption to traffic throughout construction is minimal and right-of-way is not an issue (ITE, 1989).

2.5.10 Managing Transportation Demand

The toolbox for alleviating traffic congestion provides solutions that are outside of the typical construction methods box such as the managing the transportation demand. Growth management, alternate work hours and site design to minimize traffic are some of the actions described under managing the transportation demand.

2.5.11 Growth management

Growth management is described by the ITE as the use of public policy to regulate, density, geographic pattern, location and rate of growth of development. Theoretically one can limit the trip generation of a locality to any desired level if the characteristics of the trip generations for various locations are known. The required level would be consistent with the desired level of service and capacity of the existing infrastructure. A comprehensive growth management plan is not limited to transportation actions but can incorporate programs relating to economic development, community infrastructure, housing and open space (ITE, 1989).

2.5.12 Alternate work hours

Dispersing the demand for travel over a larger time period through alternate work hour initiatives is another demand management method. Distributing the demand enables the existing road network to serve more commuters without the requirement for costly improvements to capacity. Three methods for alternate work hour programs have been identified by the ITE (1989);

Staggered hours- staggered hour's sees groups of employees starting at differing times. Spacing the start times outside of conventional work hours allows employees to travel when there is reduced demand on the public transport and road network.

Flex time- flexible working hours allows employees to select their own schedule within the company's guidelines. Such as starting between 7:00am and 9:30am and with many companies allowing their employees to vary the time each day.

Compressed work hours- giving employees the opportunity to complete the typical hours of a five-day week within four days i.e. four ten-hour days totaling the normal workweek of forty hours. The benefit comes from eliminating one day of commuting per week and the longer shifts leads to travel being outside of the conventional hours (ITE, 1989).

This type of technique requires social adjustment which can take a while to implement. Government agencies such as QDTMR already employ flexible work hours with city commuters benefiting the most.

2.5.13 Site design to minimize traffic

The predominant reason for employees travelling solo to work is the need and convenience of running errands and shopping on the journey. The ITE (1989) states that a survey of office workers in suburban employment centers indicated that sixty percent of the total respondents made at least one stop either on the way to or from the office (ITE, 1989). Site design to minimize traffic refers to the opportunity for developers and office park managers to incorporate onsite facilities such as daycare centers or convenience stores. Providing these every day services reduces the number of motorists travelling solo to and from work.

This is not common practice today and as such there is very little knowledge of the impacts that it may have. Implementing a congestion-reduction site design requires commitment from site developers or a site plan review scheme that enables officials to influence the design details (ITE, 1989).

Chapter 3: Dissertation Methodology

The objective of this dissertation was to model Cohoe Street, Toowoomba in SIDRA Intersection, specifically the intersections with Herries Street, James Street and Tourist Road. The aim of the model was to investigate the current operational capacity of the network and determine the functional lifespan. It was identified that intersections are currently at or nearing capacity, exceeding the desirable level of service as outlined by the Department of Transport and Main Roads. Optimised solutions have been investigated with the final recommendations focussing on improving network capacity and safety.

For the purpose of this dissertation the additional side streets that are located along Cohoe Street have been excluded as their contribution to the link is considered negligible. The three main intersections of Cohoe Street are with Tourist Road, Herries Street and James Street.

3.1 Data Collection

The required data to undertake this research has been sourced from the Department of Transport and Main Roads using both human resources and computer based databases. Traffic counts, Annual Average Daily Traffic volumes (AADT), Heavy Vehicle percentages, video footage of Cohoe Street and crash history for the link is the specific data that has been acquired for the model development. Each of these data requirements and their contribution is outlined below;

3.1.1 Traffic counts, AADT, Heavy Vehicle Percentage and Crash History

Traffic counts were collected for the intersections of Herries Street, James Street and Tourist Road with Cohoe Street. These counts were provided by the Department of Transport and Main Roads and were carried out using number plate recognition. The counts provide detailed traffic information pertaining to the volume and vehicle type for each designated movement and therefore will form a vital part of the model development.

The AADT for the section of Cohoe Street being investigated is approximately 15,000 vehicles per day with a heavy vehicle percentage of almost 23%. This data was obtained through the program Chartview which is a DTMR resource that captures a multitude of data types for DTMR’s entire road network. The high percentage of heavy vehicles implied that there is congestion issues with the road link.

Historical crash data for the network is one of the additional data sets that is available through Chartview this allowed for details of the crashes that have occurred at both Herries Street and James Street to be obtained. Both of the sites have had a large number of crashes over the year and this research may or may not find that the intersection type (sign controlled) had a factor in those incidents.

3.1.2 Video Data

Many of the State's major intersections have fixed video cameras monitoring them for safety purposes. The Traffic Management Centre (TMC) is a division within DTMR in Toowoomba that have the role of monitoring the cities extensive camera network. Fortunately there is a fixed camera located at the intersection of James Street and also at the top of the Range. A request was sent through via email to the TMC asking for a range of video recordings. The specified peak to record was selected as 4:00pm to 6:00pm using a 2011 traffic count at the permanent counter located approximately 100m east of James Street as a reference. The returned request provided ten hours of recordings. Due to locality of the cameras the data had to be captured over multiple days.

The video data has provided a form of validation for the outputs from the SIDRA model in relation to average delays and gap acceptance. SIDRA has the ability to be manually calibrated to suit the real life data. Calibration was not required as the average variance between the real footage and the SIDRA average delay was under ten percent. Driver behaviour will also be noted from the video data as the horizontal alignment of the link has a tight curve that requires deceleration especially for heavy vehicles to negotiate safely.

3.2 Model Development

SIDRA Intersection was used to model the individual intersections with the each site analysed individually and as network. The geometric layouts for each intersection were developed using aerial photography and Digital Video Recording (DVR) to measure the lane widths. Standard parameters for gap acceptance were adopted as SIDRA has based these from the extensive research that has been undertaken and published within the relevant AUSTROADS manuals. The vehicle characteristics namely length were modified to suit those outlined in DTMR standards. The average vehicle length was assumed as 26 metres with a queue space of 30 metres.

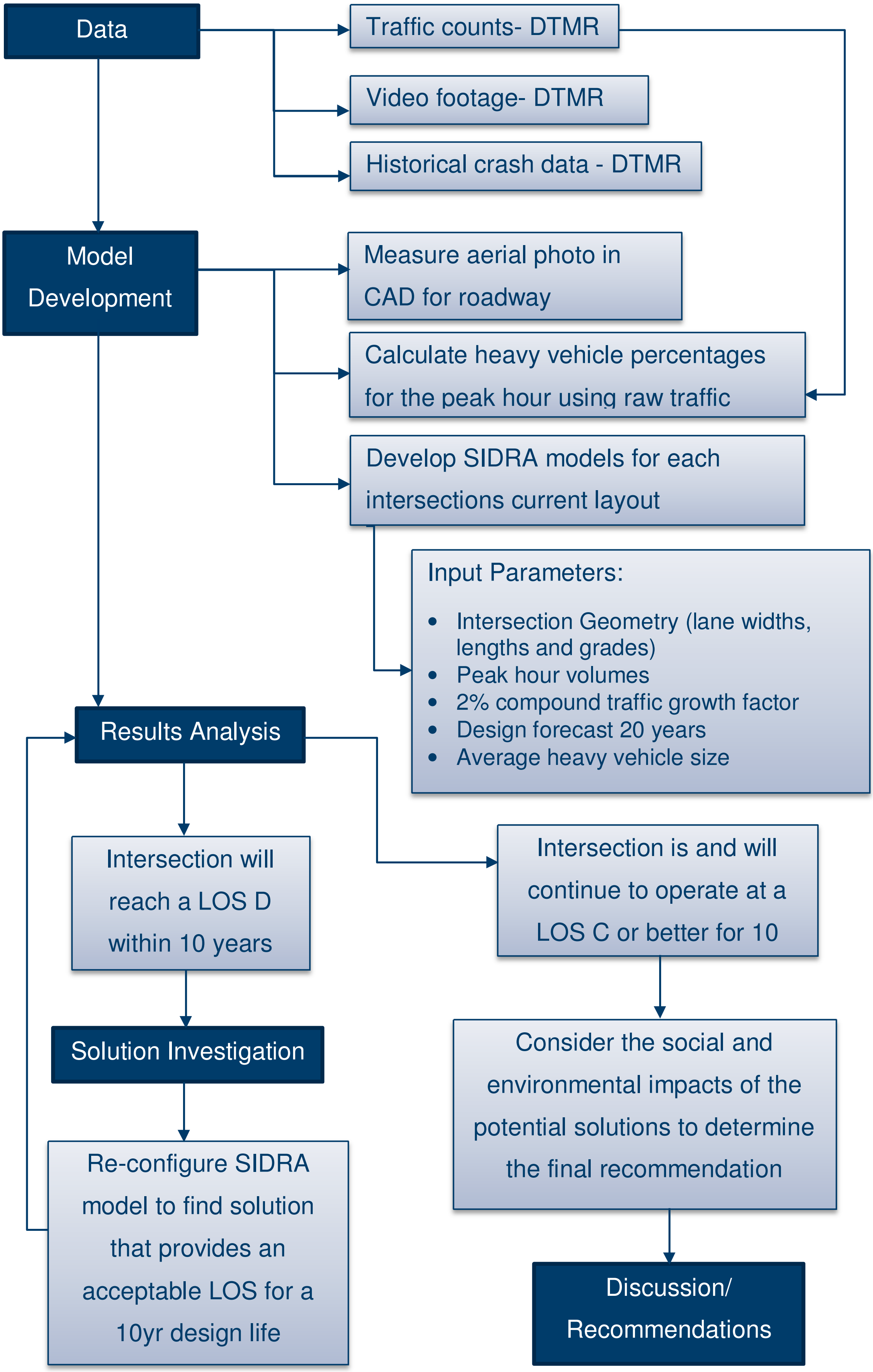
The main output required was the Level of Service for each site and the overall Level of Service for the link. The subsequent runs of the model were for a 10 and 20 year future time period using the current traffic volumes and the coinciding growth percentage. The level of service outputs determine if upgrades are required and a timeframe for improving the intersections capacity. Different options using the Road Planning and Design Manual along with the Austroads Guide to Road Design were modelled in SIDRA to develop an optimal solution. The final recommendation will not only provide an improved LOS but will aim to limit any social and environmental impacts that are typical with roadworks.

3.2.1 Assumptions

For the purpose of the investigation a standard traffic growth rate of two percent compounded has been adopted for each site. Two percent is the default value in SIDRA and is also the base line used by the Department of Transport and Main Roads. The average heavy vehicle length has been assumed as twenty six meters.

The effect on traffic volumes and composition from the planned second range crossing (Toowoomba bypass) has not been considered, as the actual impact is not quantifiable until after construction.

3.3 Methodology Flow Chart



Chapter 4: Tourist Road Model Development and Results Analysis

This chapter details the intersection of Tourist Road with Cohoe Street which shall be referred to as Site 1 from this point forward. The following chapter outlines the site layout, traffic volumes and detailed discussion of the results obtained through the model.

4.1 Geometric Properties of Site 1

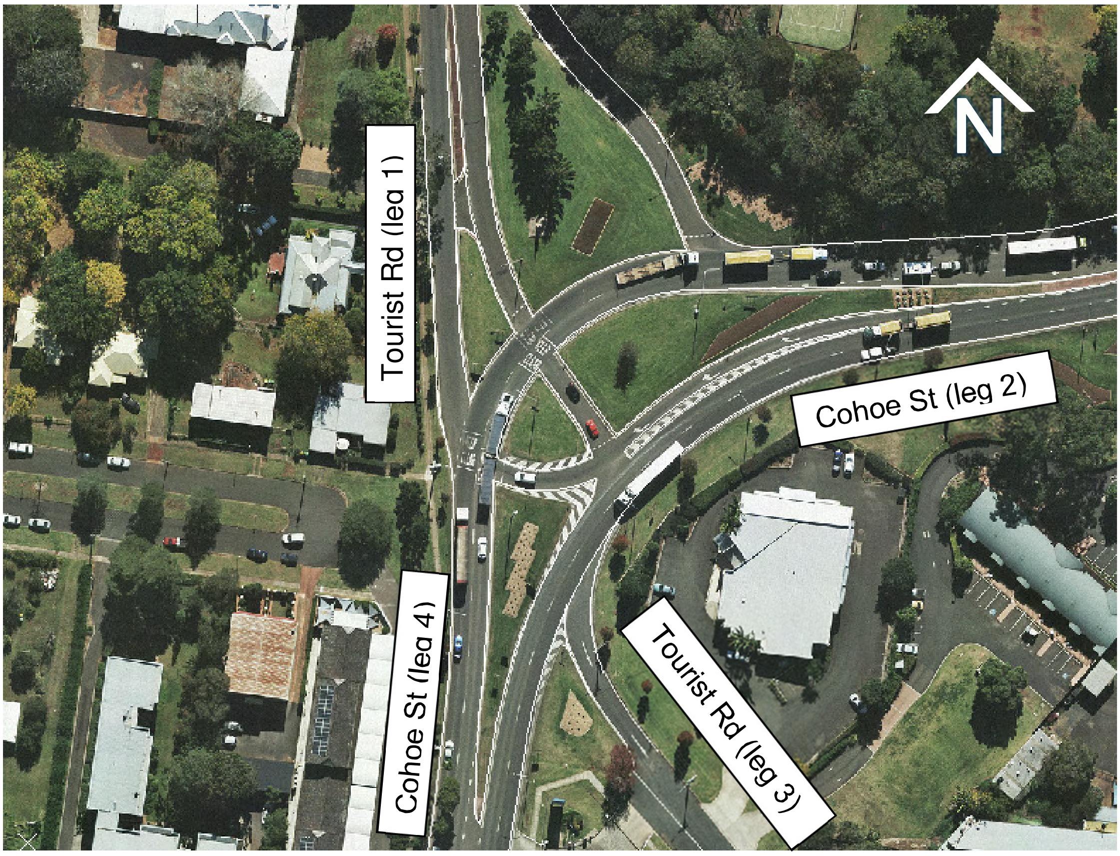


Figure 5: Aerial Photo, Intersection of Tourist Road and Cohoe Street (DTMR)

Figure 6: Photograph, Intersection of Tourist Road and Cohoe Street (K. Pearson)

The Intersection of Tourist Road and Cohoe Street is a four leg intersection as illustrated in figure 4. Standard leg naming convention has been adopted, leg 1 being to the North and subsequent leg numbering following a clockwise direction.

Tourist Road North (leg 1) has two approach lanes and one departure lane, each separated with a raised median. The through and right movements exiting Tourist Road North (leg 1) onto Cohoe Street (leg 4) are separated with a twenty metre centre median forming a staged crossing. The Warrego Highway (leg 1) approach has two through lanes and a single auxiliary right turn lane. Cohoe Street South (leg 4) has two approach lanes and leg 3 is exclusively a departure lane. Figure 7 depicts the movements of each lane. It should be noted the arrows are diagrammatical and do not represent the actual line markings of the site.

The intersection is located on relatively steep terrain with an approximate grade of 6% from the East as can be seen in figure 6. Key features of the site have been summarised in Table 2.

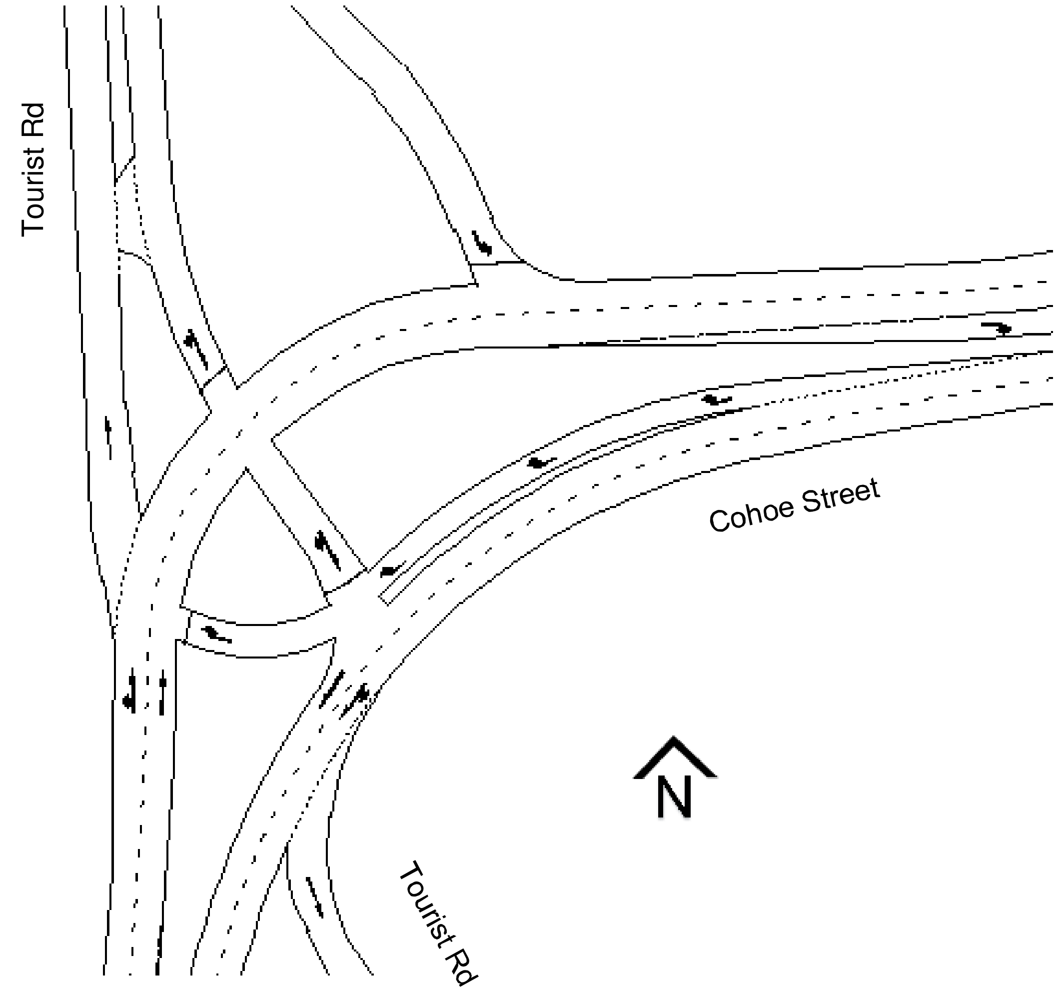


Figure 7: Site 1 Movement Definitions (K. Pearson)

Table 2: Key Geometric features of Tourist Road and Cohoe Street Intersection

Approach	Features
Tourist Road (leg 1)	• Two lanes separated by a raised median • Through and right are staged crossings with a 20m median storage • 60km/hr speed limit
Warrego Highway (leg 2)	• Two lanes plus one auxiliary right turn lane • Grade of 6% • 60km/hr speed limit
Tourist Road (leg 3)	• Exclusive departure lane • 60km/hr speed limit
Cohoe Street (leg 4)	• Two lanes • 60km/hr speed limit

4.2 Traffic Data

Twelve hour traffic counts were provided by DTMR with the peak hour flows summarised in table 3. The AM peak was identified as 7:30 to 8:30am and the PM peak as 4:30 to 5:30pm. Refer Appendix B for detailed counts.

Table 3: Tourist Road Peak Hour Summary (QDTMR)

Time Period	Cohoe Street (leg 2)					Tourist Road (leg 3)					
	Light	Rigid	Artic.	Road Train	Total	Light	Rigid	Artic.	Road Train	Total	
AM	1188	54	33	26	1301	0	0	0	0	0	
PM	778	38	40	34	890	0	0	0	0	0	
Time Period	**Cohoe Street (leg 4)**					**Tourist Road (leg 1)**					**Grand Total**
	Light	Rigid	Artic.	Road Train	Total	Light	Rigid	Artic.	Road Train	Total	
AM	528	38	37	34	637	280	12	5	1	298	**2236**
PM	773	23	21	28	845	842	2	0	0	484	**2219**

4.3 Crash History

The crash history for site one has been provided by DTMR. Fortunately there has only been one incident recorded for the site, the details are summarised in Table 4.

Table 4: Crash History Site 1

Date	Crash Severity Description	Crash Description
20/02/2009	Property damage only	Opposing vehicles; turning

4.4 Model Development

The first scenario modelled examined Tourist Road in isolation, not taking into account the planned development at Herries Street. Scenario one was run with a zero year design period as the implementation of traffic signals at Herries Street will be complete by 2016. Scenario two incorporated SIDRAs recommended bunching factor of 20% when signals are located within zero to two hundred meters downstream of a site (SIDRA Solutions 2012).

The PM peak traffic volumes were selected with a 60-minute time period. The standard peak flow of thirty minutes for a sixty-minute analyses time period was adopted. The inputs required were; geometry, sign control type, grade, speed, traffic volume, growth factor and vehicle characteristics. The main inputs remained constant for both scenarios modelled.

Modelling a staged crossing in SIDRA is done through the network function as outlined on the SIDRA Intersection website (reference) .The two stages are created as individual sites and then linked as network by the median storage area.

4.5 Results

Scenario one was modelled as the base case with no design period. Table 5 outlines the movement summary for each leg for the current year (2015), specifically the traffic volume, heavy vehicle percentage, degree of saturation, average delay, queue distance, average speed and importantly the level of service.

Table 5: Movement Summary Tourist Road, Scenario 1

	Movement	Demand Total (Veh/hr)	HV (%)	Degree. Saturation (v/c)	Av. Delay (s)	Queue distance (m)	Av. Speed (km/hr)	LOS
Warrego Highway (Leg 2)	Left	62	1.7	0.192	5.6	0	57.2	A
	Through	609	18.5	0.192	0	0	59.4	A
	Right	265	1.6	0.547	16.6	21.8	46.1	C
Cohoe St (leg 3)	Left	111	0	0.242	5.5	0	57.0	A
	Through	779	10	0.242	0	0	59.3	A
Tourist Road (leg 1)	Left	366	0.6	0.198	5.6	0	54.9	A
	Through- 1st stage	143	0	0.609	33.4	20.7	24.9	D
	Through- 2nd stage	111	0	0.198	4.4	4.8	49.9	A
	Right- 2nd stage	33	0	0.198	5.4	4.8	49.1	A

The results indicate that currently there are two movements within the site that are at or nearing capacity. The first stage of the through and right movement from Tourist Road is currently operating at a level of service D with an average delay of 33.4 seconds. Additionally the right turn from the Warrego Highway is currently operating at level of service C with an average delay of 16.6 seconds.

The large traffic volumes and high heavy vehicle percentage on leg three is the root cause of delay to those movements crossing. The crossing distance is not excessive with only two lanes totalling x metre and a drive through of the site suggested that sight distance was not influencing the selection of acceptable gaps.

Table 6 outlines the movement summary for scenario two; that is with the additional 20% bunching from the downstream signals being constructed at Herries Street.

Table 6: Movement Summary Tourist Road, 0, 10 and 20 year design period

	Move	Design Life (yrs)	Demand Total (Veh/hr)	HV (%)	Degree. Saturation (v/c)	Av. Delay (s)	Queue distance (m)	Av. Speed (km/hr)	LOS
Warrego Highway (Leg 2)	Left	0	62	1.7	0.192	5.6	0	57.2	**A**
		10	76	1.7	0.240	5.5	0	57.1	**A**
		20	92	1.7	0.293	5.5	0	57.1	**A**
	Through	0	609	18.5	0.192	0	0	59.4	**A**
		10	743	18.5	0.240	0	0	59.4	**A**
		20	906	18.5	0.293	0	0	59.4	**A**
	Right	0	265	1.6	0.456	13.6	18.6	47.9	**B**
		10	323	1.6	0.718	22.5	38.0	42.9	**C**
		20	394	1.6	1.243	257.4	406.7	11.4	**F**
Cohoe St (leg 3)	Left	0	111	0	0.242	5.5	0	57.0	**A**
		10	135	0	0.296	5.5	0	57.0	**A**
		20	1157	10	0.360	0	0	59.3	**A**
	Through	0	779	10	0.242	0	0	59.3	**A**
		10	950	10	0.296	0	0	59.3	**A**
		20	1157	10	0.36	0	0	59.3	**A**
Tourist Road (leg 1)	Left	0	366	0.6	0.198	5.6	0	54.9	**A**
		10	447	0.6	0.241	5.6	0	54.9	**A**
		20	544	0.6	0.294	5.6	0	54.9	**A**
	Through - 1st stage	0	143	0	0.481	24.9	16.1	28.0	**C**
		10	175	0	0.858	60.2	43	18.4	**F**
		20	213	0	1.746	734.9	445.2	2.4	**F**
	Through - 2nd stage	0	111	0	0.198	4.4	4.8	49.9	**A**
		10	135	0	0.292	6.3	7.8	47.3	**A**
		20	164	0	0.459	10.2	13.7	43.0	**B**
	Right- 2nd stage	0	33	0	0.198	5.4	4.8	49.1	**A**
		10	40	0	0.292	7.6	7.8	46.7	**A**
		20	48	0	0.459	10.2	13.7	42.4	**B**

The results again highlight issues with the same two movements although it is evident that the introduction of the downstream traffic signals is providing additional gaps in the traffic flow. The level of service for the first movement of the through and right out of Tourist Road has been improved to a C with an average delay of 24.9 seconds for the current year. Similarly the level of service for the right turn from the Warrego Highway has been improved to a B with an average delay of 13.6 seconds.

Table 7 below indicates a breakdown for the number of years required to reach each level of service for these two movements.

Table 7: Level of Service Summary, Site 1

	Level of Service- Year Reached (yrs.)					
Movement	**A**	**B**	**C**	**D**	**E**	**F**
Leg 2- Right	-	0	3	12	14	16
Leg 1- Through 1st stage	-	-	0	1	6	9

The first stage of the crossing movement from Tourist Road will reach a level of service D within one year and a level service E within six years meaning that capacity improvements are warranted. The right turn from the Warrego Highway will reach a LOS C within 3 years and LOS D within 6 years also warranting capacity improvements.

Prioritizing improvements is not only based on the level of service, traffic volumes also need to be taken into considerations as often funding may not be available to complete all upgrades simultaneously. The Warrego Highway has 265 vehicles per hour turning right whereas the first stage crossing movement from Tourist Road has 143 vehicles per hour. A wider cross section of the community may benefit more if leg two was prioritized first if required.

4.6 Validation

Validation of the SIDRA results was conducted by manually timing video footage from a permanent traffic monitoring camera. The average delay from the footage was found to be 27.7 seconds for vehicles crossing the highway from Tourist Road. In comparison SIDRA calculated the delay as 24.9 seconds giving a variance of 9.8%. Due to the nature of software modelling this variance has been accepted and as such the default parameters in SIDRA will not be calibrated further.

Chapter 5: Herries Street Model Development and Results Analysis

This chapter details the intersection of Herries Street with Cohoe Street which shall be referred to as Site 2 from this point forward. This chapter outlines the site layout, traffic volumes and detailed discussion of the results obtained through the model.

5.1 Current Geometric Properties Site 2

Figure 8: Aerial Photo, Intersection of Herries Street and Cohoe Street (DTMR)

Figure 9: Photograph, Intersection of Herries Street and Cohoe Street (K.Pearson)

The intersection of Herries Street and Cohoe Street is a sign controlled four leg intersection as illustrated in figure 8. Cohoe Street North (leg 1) has two approach lanes, an auxiliary right turn lane and two departure lanes. The left and through movements share the left lane. Herries Street East (leg 2) has one approach lane that has all movements allocated (left, through and right) and one departure lane. Cohoe Street (leg 3) has the same configuration as Cohoe Street North, being two approach lanes, an auxiliary right turn lane and two departures lanes. Herries Street (leg 4) consists of one approach lane in which left out is the only permitted movement and a single departure lane. Figure 10 depicts the movements of each lane. It should be noted the arrows are diagrammatical and do not represent the actual line markings of the site.

The intersection is located on a mild grade of approximately -4% from the North to the South with each leg having a speed limit of 60km/hr. Key geometric features of the intersection are summarised in Table 8.

There is a new development on the North West that is currently under construction with plans to implement traffic signals. The new layout will see movements into and out of Herries Street East (leg 2) restricted to left in and left out only. The auxiliary right turn lane on Cohoe Street South will be removed with a left slip lane being added. It should be noted that the traffic heading south from Cohoe Street North would not be affected by the signals, essentially receiving a continual green phase.

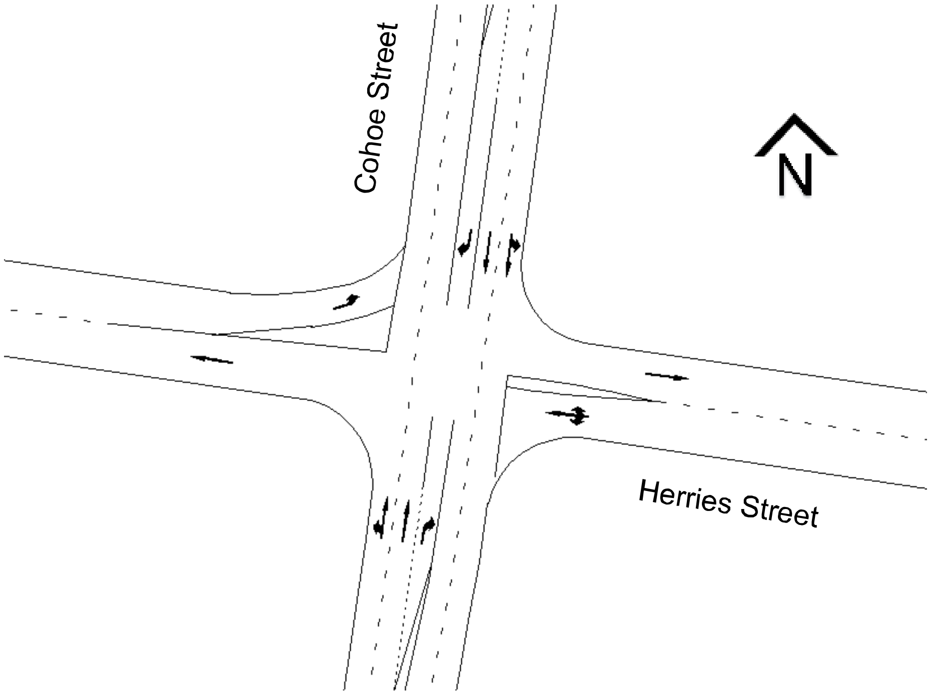


Figure 10: Site 2 Movement Definitions (K. Pearson)

Table 8: Key Geometric Features Site 2

Approach	**Features**
Cohoe Street (leg 1)	• Two lanes and an auxiliary right turn lane • 60km/hr speed limit • Downgrade of approximately -4%
Herries Street (leg 2)	• Single lane • 60km/hr
Cohoe Street (leg 3)	• Two lanes and an auxiliary right turn lane • 60km/hr • Grade of approximately +4%
Herries Street (leg 4)	• One lane, left out only • 60km/hr speed limit

5.2 Traffic data

Twelve hour traffic counts were provided by DTMR with the peak hour flows summarised in Table 9. The AM peak was identified as 7:45 to 8:45am and the PM peak as 4:30 to 5:30pm. Refer Appendix B.3 for detailed counts.

Table 9: Site 2 Peak Hour Summary

Time Period	**Cohoe Street (leg 1)**					**Herries Street (leg 2)**					
	Lights	Rigid	Artic.	Road Train	**Total**	Lights	Rigid	Artic.	Road Train	**Total**	
AM	816	49	33	29	**927**	26	0	0	0	**26**	
PM	525	42	46	25	**638**	27	0	0	0	**27**	
Time Period	**Cohoe Street (leg 3)**					**Herries Street (leg 4)**					**Grand Total**
	Lights	Rigid	Artic.	Road Train	**Total**	Lights	Rigid	Artic.	Road Train	**Total**	
AM	518	33	46	32	**629**	64	2	1	0	**67**	**1649**
PM	625	24	24	27	**700**	174	3	0	0	**177**	**1542**

Table 10: Site 2 PM Peak Hour Summary with Development Contributions

Time Period	**Cohoe Street (leg 1)**				**Herries Street (leg 2)**				
	Lights	Heavy Vehicles	**Total**		Lights	Heavy Vehicles	**Total**		
PM	540	114	**654**		53	0	**53**		
Time Period	**Cohoe Street (leg 3)**				**Herries Street (leg 4)**				**Grand Total**
	Lights	Heavy Vehicles	**Total**		Lights	Heavy Vehicles	**Total**		
PM	739	11	**750**		229	4	233		**1690**

5.3 Crash History

The crash history for site two has been provided by DTMR. Sadly there has been one fatality at the site in 1994. The historical data is summarised in Table 11.

Table 11: Crash History Site 2 (DTMR)

Date	Crash Severity Description	Crash Description
18/02/2011	Minor Injury - First Aid Or No Treatment	Veh's Opposite Approach: Thru-Right
5/03/2010	Minor Injury - First Aid Or No Treatment	Veh's Same Direction: Left Rear
4/05/2007	Property Damage Only	Veh's Same Direction: Left Rear
11/10/2005	Admitted To Hospital	Veh's Opposite Approach: Thru-Right
30/04/2004	Received Medical Treatment - Not Admitted	Veh's Adjacent Approach: Thru-Thru
16/12/2002	Property Damage Only	Veh's Opposite Approach: Thru-Right
24/08/2002	Property Damage Only	Veh's Adjacent Approach: Thru-Thru
14/07/2002	Received Medical Treatment - Not Admitted	Veh's Adjacent Approach: Thru-Thru
10/07/2002	Received Medical Treatment - Not Admitted	Veh's Adjacent Approach: Thru-Left
19/06/2002	Property Damage Only	Veh's Same Direction: Right Rear
25/09/2001	Minor Injury - First Aid Or No Treatment	Veh's Adjacent Approach: Thru-Right
28/08/2001	Property Damage Only	Veh's Adjacent Approach: Thru-Thru
13/07/2001	Admitted To Hospital	Veh's Opposite Approach: Thru-Right
4/08/2000	Property Damage Only	Veh's Adjacent Approach: Thru-Thru
17/06/1998	Received Medical Treatment - Not Admitted	Veh's Adjacent Approach: Thru-Thru
14/12/1996	Admitted To Hospital	Veh's Adjacent Approach: Thru-Thru
6/04/1996	Property Damage Only	Veh's Adjacent Approach: Thru-Thru

15/10/1995	Received Medical Treatment - Not Admitted	Veh's Adjacent Approach: Thru-Thru
21/08/1995	Property Damage Only	Veh's Same Direction: Right Turn S/Swipe
12/02/1995	Property Damage Only	Veh's Adjacent Approach: Thru-Thru
25/08/1994	Property Damage Only	Veh's Adjacent Approach: Thru-Thru
18/06/1994	Admitted To Hospital	Veh's Adjacent Approach: Thru-Thru
14/06/1994	Fatal	Veh's Adjacent Approach: Thru-Thru
1/07/1993	Property Damage Only	Veh's Opposite Approach: Thru-Right
12/03/1993	Property Damage Only	Veh's Adjacent Approach: Thru-Thru
4/03/1993	Property Damage Only	Veh's Adjacent Approach: Thru-Thru
13/03/1992	Property Damage Only	Veh's Adjacent Approach: Thru-Thru

5.4 Model Development

Scenario one investigated the existing sign controlled configuration with a zero year design period as the implementation of traffic signals is due for completion in early 2016. Traffic volumes were input based on the counts obtained this year (2015). Scenario two modelled the planned layout with signalisation, taking into account the additional traffic volumes identified by the developer. Zero, ten and twenty year design periods were selected for scenario two. The PM peak traffic volumes were selected with a 60-minute time period. The standard peak flow of thirty minutes for a sixty-minute analyses time period was adopted. The inputs required were; geometry, sign control type, grade, speed, traffic volume, growth factor and vehicle characteristics. The key input changes between the two scenarios are the traffic volumes, the control type (sign to signals), lane configuration and movement definitions.

5.5 Results

Scenario one was modelled as the base case with no design period. Table 12 outlines the movement summary for each leg for the current year (2015), specifically the traffic volumes, heavy vehicle percentage, degree of saturation, average delay, queue distance, average speed and importantly the level of service.

Table 12: Movement Summary Site 2, Current Year, 2015 (without development)

	Movement	Demand Total (Veh/hr)	HV (%)	Degree. Saturation (v/c)	Av. Delay (s)	Queue distance (m)	Av. Speed (km/hr)	LOS
Cohoe St (leg 1)	Left	2	0	0.164	5.5	0	58.3	**A**
	Through	571	19.6	0.164	0	0	59.9	**A**
	Right	99	7.5	0.170	10.7	5.4	49.5	**B**
Herries St (leg 2)	Left	7	0	0.718	94.9	16.9	15.1	**F**
	Through	9	0	0.718	165.6	16.9	15.1	**F**
	Right	12	0	0.718	247.5	16.9	15.1	**F**
Cohoe St (leg 3)	Left	12	0	0.196	5.5	0	58.1	**A**
	Through	711	11	0.196	0	0	59.9	**A**
	Right	15	0	0.020	10.7	0.5	51.2	**A**
Herries St (leg 4)	Left	185	1.7	0.204	7.5	5.8	52	**A**

The results indicate that currently one leg is operating at or above capacity with the remaining legs operating acceptably. Herries Street East has all exiting movements assigned to one lane, as such all movements are currently failing that is through, right and left out. The average delay for the left out is approximately 94.9 seconds, 165.6 seconds for the through movement and 247.5 seconds for the right out. These large delays equates to a level of service F for each movement.

The right turn out of Herries Street East has to cross two lanes of traffic with the through movement requiring crossing five lanes of traffic. The crossing distance and volume of traffic along Cohoe Street North and South is the likely cause of the delays to those vehicles exiting Herries Street East.

The reconfigured layout that is due for completion early 2016 as a part of a new fast food precinct will see the exiting movements out of Herries Street East restricted to left in and left out only. Scenario two investigated this option including the additional predicted traffic volumes attributed to the new development. Table 13 outlines the movement summary for scenario two for the zero, ten and twenty year design periods analysed

Table 13: Movement Summary Site 2, 0, 10 and 20 Year Design Period (with signalisation)

	Movement	Design Life (yrs)	Demand Total (Veh/hr)	HV (%)	Degree. Saturation (v/c)	Av. Delay (s)	Queue distance (m)	Av. Speed (km/hr)	LOS
Cohoe St (leg 1)	Left	0	7	0	0.236	7.2	9.9	56.1	**A**
		10	9	0	0.288	7.2	12.5	56.1	**A**
		20	11	0	0.351	7.3	16.1	55.9	**A**
	Through	0	491	18.9	0.236	1.6	9.9	57.7	**A**
		10	598	18.9	0.288	1.7	12.5	57.6	**A**
		20	729	18.9	0.351	1.8	16.1	57.5	**A**
	Right	0	215	5.7	0.310	8.8	11.3	51.0	**A**
		10	262	5.7	0.400	10.0	16.8	50.2	**A**
		20	319	5.7	0.526	11.7	24.5	49.0	**B**
Herries St (leg 2)	Left	0	42	17	0.041	7.1	1.4	51.6	**A**
		10	51	17.0	0.050	7.2	1.7	51.6	**A**
		20	63	17	0.061	7.2	2.1	51.6	**A**
Cohoe St (leg 3)	Left	0	100	0	0.570	13.1	36.1	50.9	**B**
		10	122	0	0.699	14.8	51.9	49.9	**B**
		20	149	0	0.769	14.7	73.9	48.8	**B**
	Through	0	679	14.5	0.570	739	48.3	52.7	**A**
		10	825	14.5	0.699	9.7	68.8	51.3	**A**
		20	1009	14.5	0.769	11.7	84.3	50.1	**B**
Herries St (leg 4)	Left	0	245	4.2	0.328	17.6	13.1	45.4	**B**
		10	299	4.2	0.400	17.9	16.2	45.3	**B**
		20	364	4.2	0.488	18.1	20.2	45.2	**B**

The results now indicate that the entire site will operate effectively for a twenty-year design period. The implications of restricting the turn movements from Herries Street East has not been investigated in this report as this formed a part of the development application process, and as such would have been considered.

Chapter 6: James Street Model development and Results Analysis

This chapter details the intersection of James Street with Cohoe Street which will be referred to as Site 3 from this point forward. This chapter outlines the site layout, traffic volumes and detailed discussion of the results obtained through the model.

6.1 Intersection Layout

Figure 11: Aerial photo, Intersection of James Street and Cohoe Street (DTMR)

Figure 12: Photograph, Intersection of James Street and Cohoe Street (K. Pearson)

The intersection of James Street and Cohoe Street is a three leg sign controlled intersection as illustrated in figure 15. Cohoe Street (leg 1) has two approach lanes and two departure lanes that are separated by a raised median. James Street (leg 2) has two approach lanes although the definition of the two lanes is relatively short. The approach and departure lanes are separated by a raised concrete median. Cohoe Street (leg 3) consists of two approach lanes and an auxiliary right turn lane that is separated by a concrete median. Figure 13 highlights the movement definitions of the site. Note the arrows are diagrammatical only to indicate movement and do not represent the actual line marking of the site. Key geometric features of the site are summarised in Table 14.

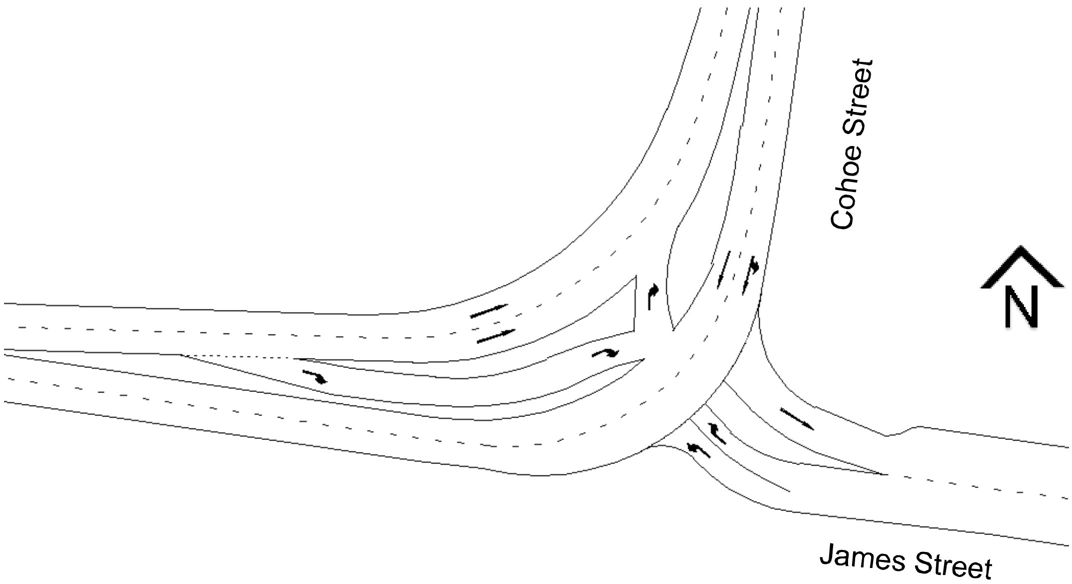


Figure 13: Site 3 Movement Definitions (K. Pearson)

Table 14: Key Geometric Features Site 3

Approach	Features
Cohoe Street (leg 1)	• Two lanes • Downgrade of approximately -4% • 60km/hr speed limit
James Street (leg 2)	• Two lanes • Right turn is a staged crossing with a 7m median storage • 60km/hr speed limit
Cohoe Street (leg 3)	• Two lanes and an auxiliary right turn lane • 60km/hr speed limit

6.2 Traffic data

Twelve hour traffic counts were provided by DTMR with the peak hour flows summarised in Table 15. The AM peak was identified as 7:45 to 8:45am and the PM peak as 3:15 to 4:15pm. Refer Appendix B.4 for detailed counts.

Table 15: James Street Peak Hour Summary

Time Period	Cohoe Street (leg 1)					James Street (leg 2)					
	Lights	Rigid	Artic.	Road Train	Total	Lights	Rigid	Artic.	Road Train	Total	
AM	531	39	30	32	**632**	424	7	4	0	**435**	
PM	407	28	31	37	**503**	307	5	1	0	**313**	
Time Period	**Cohoe Street (leg 3)**										
	Lights	Rigid	Artic.	Road Train	Total						**Grand Total**
AM	407	37	45	34	**523**						**1590**
PM	728	31	32	31	**822**						**1638**

6.3 Crash History

The crash history for site two has been provided by DTMR and summarised in Table 16. Out of all the incidents on record 32% can most likely be attributed to the geometric properties of the site. Drivers often underestimate the reduction in speed required to safely traverse the tight horizontal curve.

Table 16: Crash History Site 2 (DTMR)

Date	Crash Severity Description	Crash Description
9/08/2010	Minor Injury - First Aid Or No Treatment	Veh's Adjacent Approach: Right-Right
9/08/2010	Minor Injury - First Aid Or No Treatment	Veh's Adjacent Approach: Right-Right
6/06/2010	Property Damage Only	Veh's Adjacent Approach: Right-Right
28/03/2010	Property Damage Only	Veh's Adjacent Approach: Right-Right
20/10/2009	Property Damage Only	Veh's Adjacent Approach: Right-Right
17/09/2009	Property Damage Only	Off Path-Curve: Out Of Control On Cway
13/02/2009	Property Damage Only	Veh's Same Direction: Lane Side Swipe
13/02/2009	Property Damage Only	Off Path-Curve: Off Cway Rt Bend Hit Obj
18/11/2008	Property Damage Only	Veh's Opposite Approach: Thru-Right
5/08/2008	Property Damage Only	Veh's Adjacent Approach: Right-Right
13/07/2008	Property Damage Only	Off Path-Curve: Off Cway Rt Bend Hit Obj
16/03/2008	Property Damage Only	Off Path-Curve: Off Cway Rt Bend Hit Obj
4/11/2007	Admitted To Hospital	Off Path-Curve: Out Of Control On Cway
15/10/2007	Property Damage Only	Veh's Adjacent Approach: Thru-Right
10/06/2006	Property Damage Only	Off Path-Straight: Other
4/04/2005	Received Medical Treatment - Not Admitted	Off Path-Curve: Out Of Control On Cway
9/02/2005	Property Damage Only	Veh's Adjacent Approach: Thru-Right
8/10/2004	Property Damage Only	Veh's Adjacent Approach: Right-Right
15/09/2004	Property Damage Only	Veh's Opposite Approach: Thru-Right
11/07/2004	Property Damage Only	Off Path-Curve: Mounts Traffic Island

10/06/2004	Property Damage Only	Veh's On Path: Temporary Object On C'way
29/03/2004	Property Damage Only	Off Path-Curve: Mounts Traffic Island
20/03/2004	Admitted To Hospital	Off Path-Curve: Off Cway Rt Bend Hit Obj
20/11/2003	Property Damage Only	Veh's Adjacent Approach: Thru-Right
26/09/2003	Property Damage Only	Off Path-Curve: Mounts Traffic Island
23/08/2003	Minor Injury - First Aid Or No Treatment	Veh's Same Direction: Right Rear
29/05/2003	Property Damage Only	Veh's Adjacent Approach: Other
28/02/2003	Property Damage Only	Veh's Opposite Approach: Right-Right
3/09/2002	Property Damage Only	Veh's Adjacent Approach: Right-Right
5/08/2002	Property Damage Only	Veh's Adjacent Approach: Right-Right
9/06/2002	Minor Injury - First Aid Or No Treatment	Off Path-Curve: Out Of Control On Cway
7/06/2002	Property Damage Only	Veh's Adjacent Approach: Right-Thru
31/10/2000	Property Damage Only	Off Path-Curve: Out Of Control On Cway
21/10/2000	Property Damage Only	Off Path-Curve: Off Cway Rt Bend Hit Obj
6/10/2000	Admitted To Hospital	Veh's Opposite Approach: Thru-Right
20/01/2000	Minor Injury - First Aid Or No Treatment	Off Path-Curve: Out Of Control On Cway
1/05/1999	Property Damage Only	Off Path-Straight: Left Off Cway Hit Obj
2/06/1998	Received Medical Treatment - Not Admitted	Off Path-Straight:Out Of Control On Cway
22/12/1997	Property Damage Only	Off Path-Straight: Right Off Cway
25/11/1997	Received Medical Treatment - Not Admitted	Off Path-Straight: Left Turn
19/10/1996	Property Damage Only	Veh's Opposite Approach: Thru-Right
28/09/1996	Property Damage Only	Off Path-Straight:Right Off Cway Hit Obj
4/08/1994	Property Damage Only	Veh's Adjacent Approach: Right-Thru
22/07/1994	Property Damage Only	Off Path-Curve: Out Of Control On Cway
6/10/1993	Property Damage Only	Veh's Adjacent Approach: Right-Thru
28/06/1993	Minor Injury - First Aid Or No Treatment	Off Path-Straight: Right Off Cway
27/12/1992	Property Damage Only	Off Path-Curve: Out Of Control On Cway
21/06/1992	Property Damage Only	Veh's Adjacent Approach: Right-Right
7/01/1991	Property Damage Only	---

8/11/1990	Property Damage Only	---
10/10/1990	Property Damage Only	---
29/07/1990	Property Damage Only	---
20/04/1990	Property Damage Only	---

6.4 Model Development

Only one scenario was identified as requiring modelling that is the current layout. There are no planned improvements within the vicinity that will impact on the intersection of James and Cohoe Street. Typically when signals are located within 200 to 400 meters of a site a bunching factor of 10% will be incorporated. In this particular situation the planned signalisation of Herries Street will not influence James Street due to the southbound traffic receiving priority (continual green phase).

The PM peak traffic volumes were selected with a 60-minute time period. The standard peak flow of thirty minutes for a sixty-minute analyses time period was adopted. The inputs required once again were; geometry, sign control type, grade, speed, traffic volume, growth factor and vehicle characteristics. A zero, ten and twenty-year design period were selected for the analyses.

The right turn out of James Street onto Cohoe Street is a staged crossing with a central median of approximately seven meters. Similarly with Tourist Road this requires the site to be modelled as a network with the two stages of the crossing being modelled as individual sites and then linked as a network by the median storage area.

6.5 Results

Scenario one was modelled for each of the chosen design periods. Table 17 outlines the movement summary for each leg specifically the traffic volume, heavy vehicle percentage, degree of saturation, average delay, queue distance, average speed and importantly the level of service.

Table 17: Movement Summary Site 3, 0, 10 and 20 year design period

	Movement	Design Life (yrs)	Demand Total (Veh/hr)	HV (%)	Degree. Saturation (v/c)	Av. Delay (s)	Queue distance (m)	Av. Speed (km/hr)	LOS
Cohoe St (leg 1)	Left	0	68	0	0.182	5.5	0	57.7	**A**
		10	83	0	0.221	5.5	0	57.0	**A**
		20	102	0	0.270	5.5	0	57.0	**A**
	Through	0	559	21.3	0.182	0	0	59.3	**A**
		10	681	21.3	0.221	0	0	59.3	**A**
		20	831	21.3	0.270	0	0	59.3	**A**
James street (leg 2)	Left	0	177	3.0	0.165	9.5	5.3	51.6	**A**
		10	216	3.0	0.215	9.9	7.0	51.0	**A**
		20	263	3.0	0.287	10.6	9.8	50.6	**B**
	Right- 1st stage	0	153	0.7	0.503	24.8	17.3	27.9	**C**
		10	186	0.7	0.882	62.0	48.4	18.0	**F**
		20	227	0.7	1.744	729.1	479.8	2.4	**F**
	Right- 2nd stage	0	153	0.7	0.211	3.4	4.0	48.2	**A**
		10	186	0.7	0.313	5.5	6.7	45.8	**A**
		20	227	0.7	0.496	9.6	12.0	41.6	**A**
Cohoe St (leg 3)	Through	0	724	15.8	0.205	0	0	60	**A**
		10	883	15.8	0.250	0	0	59.9	**A**
		20	1076	15.8	0.304	0	0	59.9	**A**
	Right	0	346	0.9	2.509	12.4	23.0	48.7	**B**
		10	422	0.9	0.758	19.8	47.5	44.3	**C**
		20	515	0.9	1.210	219.5	476.3	13.0	**F**

The results indicate that there are two legs with concerning movements. These movements are either at or nearing capacity within the design period. The right turn from Cohoe Street South into James Street is currently operating at a level of service B with an average delay of 12.4 seconds. This will reduce to a level of service C at the ten-year mark and then further reduce to a level of service F at the twenty-year mark with an average delay expected of 219.5 seconds.

The first stage of the right movement from James Street onto Cohoe Street North is currently operating at a level of service C with an average delay of 24.8 seconds. This will drastically reduce to a level of service F within a ten-year period with an average delay of 48.4 seconds at the final ten-year mark.

As with Tourist Road the sheer volume of traffic on Cohoe Street is likely the cause of the delay as the crossing distance for both concerning movements is only two lanes of traffic. To further understand the operation of the concerning movements the year at what each level of service from A to F will be reached was identified. The details of the level of service reached are outlined in table 18.

Table 18: Level of Service Summary, Site 3

	Level of Service- Year Reached (yrs.)					
Movement	**A**	**B**	**C**	**D**	**E**	**F**
Leg 3- Right	-	0	6	13	15	16
Leg 2- Right 1st stage	-	-	0	1	6	9

The right turn from Cohoe Street South onto James Street is currently operating at level of service B reducing to a level of service C in 6 years, a D in thirteen years and finally a level of service F in sixteen years. The first stage of the right from James Street onto Cohoe Street North is currently operating at a level of service C reducing to a D in one year and reaching a level of service of F in nine years.

As previously identified it is the sheer volume of traffic travelling through Cohoe Street that is causing the difficulties in crossing from side streets. Although the operation of the right turn from Cohoe Street into James Street will eventually dissipate it is not considered paramount that upgrades be undertaken until such time. However, if improvements can be implemented that would benefit both movements simultaneously it should be given serious consideration.

The right turn movement from James Street to Cohoe Street will require upgrading as soon as feasible to reduce community frustration as this movement carries large volumes.

6.6 Validation

Validation of the SIDRA results was conducted by manually timing video footage from a permanent traffic monitoring camera. The average delay from the footage was found to be 24.8 seconds for vehicles turning right out of James Street. In comparison SIDRA calculated the delay as 26.0 seconds giving a variance of 4.7%. Due to the nature of software modelling this variance has been accepted and as such the default parameters in SIDRA will not be calibrated further.

Chapter 7: Options Investigation

The investigation into the operational characteristics of Cohoe Street has identified that the intersections of Tourist Road and James Street both have movements that are at or reaching capacity. The following chapter aims to investigate potential options to improve traffic flow along the link.

The primary objective of this project is to identify the feasibility of improving traffic flow on Cohoe Street. As such the solution exploration is centred around a holistic local area traffic management plan (LATM) rather than focusing on the individual intersections in isolation.

The Austroads Guide to Traffic Management Part 8: Local Area Traffic Area Management defines LATM as being concerned with the planning and management of the usage of the road space within a local traffic area, often to modify streets and networks that were originally designed in ways that are now no longer considered appropriate to the needs of the users of the local area (Austroads, 2008).

In any situation there are always multiple solutions to a problem. The process of options analysis aims to identify the available solutions, determine their feasibility and ultimately reach a final recommendation that best satisfies the defined objectives. The fundamental considerations when planning road link upgrades include but not are not limited to, social, environmental and economic concerns.

The social and environmental implications of altering the road network are often interlinked with the surrounding road environment for example, in residential areas, creating a social setting where children and neighbours interact. The community's perception of a desirable street is often one which has low traffic volumes that encourages social activities such as walking and cycling. It is imperative that the perspective of all parties involved is taken into consideration when implementing a local area traffic management plan for these such reasons.

Cohoe Street is a complex situation being that it is not only a highway but also a designated heavy vehicle route that runs through the city centre of a major regional city. The area is a mix of residential and temporary accommodation with commercial businesses such as service stations, a shopping centre, hospital and schools also in the vicinity. The predominant land use is residential with all of the adjoining road links connecting residential suburbs. As such, avoiding re-directing traffic onto local residential streets is difficult but the solutions identified will try and reduce the severity of the impact to those residents.

Three main options have been identified for comparison with each option being centred around a primary signalised intersection in conjunction with access control at other locations. Option A will focus on the upgrade of the current signalised intersection of Mackenzie Street and Cohoe Street that is located 430 metres downstream of the James Street Intersection. Option B will be focused around introducing traffic signals at the intersection of Curzon Street and Cohoe Street that is currently sign controlled. Option C will investigate altering the planned signalisation of Herries Street and Cohoe Street to reconfigure it as a four way intersection. Options A, B and C all incorporate some form of movement restriction at both Tourist Road and James Street, although differing traffic diversion routes will result.

7.1 Alternate Options

Alternate options to that of A, B and C mentioned above were considered in the initial phase of the options investigation. Converting Tourist Road to a roundabout was one such option but due to the heavy vehicle route designation, the steep grade and restrictive road reserve the option was deemed unfeasible. Road trains require a large radius roundabout to be able to navigate safely around and to maintain a reasonable speed. Heavy vehicles are also restrictive in their ability to gain momentum if stopped or required to reduce speed on a steep upgrade, meaning that a roundabout simply would not function efficiently in this particular situation. Similarly, implementing traffic signals at Tourist Road will result in the same complications as a roundabout due to the traffic composition and steep grade.

Introducing traffic signals for the south bound traffic at James Street was also considered. The SIDRA modelling identified that if signalisation was implemented the right turn from Cohoe Street would still operate at a level of service F for the ten year design period. Refer Appendix D for the SIDRA movement summary for the investigated signalisation of James Street.

Typically, road authorities try to maintain free flow conditions for the through movement of Highways. Implementing traffic signals would be contradictory to this practice and would likely generate resistance from the community as experienced with the development application at Herries Street.

7.2 Options Selected for Comparison

Option A, B and C were ultimately selected for comparison as they have the greatest potential for achieving the core objective of improving traffic flow on Cohoe Street. Each option will now be discussed in detail.

7.2.1 Option A

Option A consists of a number of smaller components in combination to construct an overall plan for the Cohoe Street link. Mackenzie Street is the core intersection that will be built upon. Table 19 outlines the key components that form Option A.

Table 19: Option A Summary

Intersection	Proposed changes
Mackenzie Street	• Introduce auxiliary right turn lanes on Cohoe Street East and West • Alter the signal phasing to include right turn movements
James Street	• Restrict access to left in and left out only • Alternative route via Mackenzie Street
Tourist Road	• Restrict access to left in and left out only • Alternative access to city via Herries Street

The intersection of Mackenzie Street and James Street is located 430 metres downstream of James Street and is currently signalised. There are dual approach lanes on each leg with no auxiliary turn lanes currently provided.

The first component of Option A involves upgrading the road width to include auxiliary right turn lanes on the both Cohoe Street East and West. Introducing right turn lanes enables an alternate route for traffic being diverted from restricting turn movements at James Street.

Extensive road works would be required to gain the required extra width including constructing retaining walls, replacing traffic signal infrastructure, relocating power poles, earthworks and pavement rehabilitation. All of these are typical in an urban roadwork project but are associated with large initial costs including traffic management, construction and also the general disturbance to the community throughout the construction period.

The intersection has known sight distance issues and its location is not ideal but the base infrastructure is already in place making it the obvious choice for improvements. If the Road Authorities begin work on an existing piece of road infrastructure they are obligated to undertake all of the relevant sight distance and geometric checks to determine if the site conforms to current standards. If it is deemed to not comply they must aim to improve the site conditions or seek Engineering sign off for what is called a design exception.

The next component of Option A is restricting access at James Street. The SIDRA investigation identified that currently the right turn out of James is operating at a level of service C and will reduce to a D in one year. The right turn off the highway into James Street is also nearing capacity, albeit at a slower rate. It is suggested that access out of James Street be restricted to left out only. The right turn from Cohoe Street into James Street is also recommended as being removed. This could be undertaken in a staged process, allowing the right turn in to continue until the capacity of the movement is eventually exceeded.

The traffic that is currently turning right to head North on Cohoe Street would be given the opportunity to do so at Mackenzie Street with the introduction of right turns lanes and associated signal phasing. Road users would have the option to either turn left out of James Street and make the right turn movement from Cohoe Street onto Mackenzie or travel along local Streets Burke and Crown that lead to Mackenzie where they could then continue straight through to cross Cohoe Street. Each of these diverted routes can be seen in Figure 14.

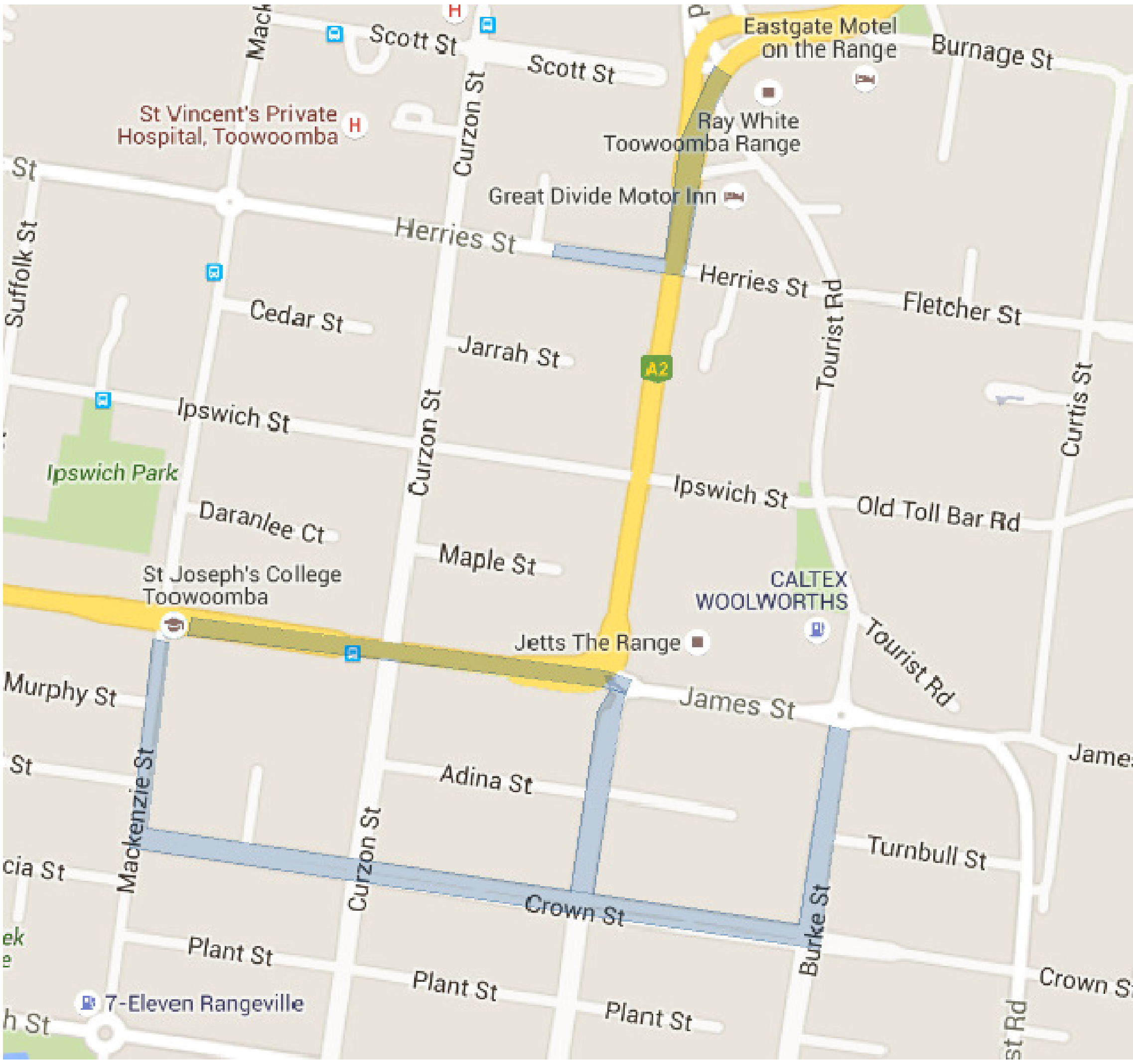


Figure 14: Possible Alternative Routes for Restricted Access at James Street & Right Turn Diversion from Tourist Road to Herries Street (Option A) (Google Maps, 2015).

The final component of Option A involves limiting access at Tourist Road. Similarly to James Street the SIDRA analyses identified the right turn from Cohoe Street East onto Tourist Road as nearing capacity within the twenty-year design life period. Also, the right turn from Tourist Road onto Cohoe Street which will reach a level of service F in nine years.

It is suggested that the access to Tourist Road be restricted to left in and left out only. The traffic that is currently turning right from Cohoe Street will be diverted to the planned signals at Herries Street (refer figure 14) which are due for construction in 2016. The additional volumes that would be generated at Herries Street would not impact on the functionality of the intersection but the queue length for the right turn would need to be evaluated in the future and potentially extended. For the through and right turning movements from Tourist Road there is no direct alternate route available assuming that the traffic is travelling directly from north east of Margaret Street. It is likely that once motorists become aware of the congestion issues they will seek an alternate route themselves to reach the south east corner of the city.

Diverting traffic onto local streets is not without issue. There must be demonstrated value for the community for it not to be met with resistance. The existing road hierarchy for the Toowoomba Region is available from the Toowoomba Regional Council. There are varying road classifications within the hierarchy ranging from local streets to arterials and highways. Mackenzie Street is identified as a distributor road. Distributor roads serve the purpose of linking local streets to higher order arterial roads. Mackenzie Street is therefore a more suitable choice for traffic diversion as distributors are expected to carry a higher traffic volume than local streets. However, residents may not be aware of this hierarchy and may oppose the additional volumes that would be generated. Community consultation is a vital process that allows the community to voice their concerns such as increases in traffic and noise pollution. The road authorities then have the opportunity to take the feedback and come back with a revised solution that meets the objectives while still remaining equitable. Local government authorities may also show opposition to arterial traffic being diverted through their local network. One method of reaching an understanding between the community and councils can be through negotiating a trade-off i.e. traffic will increase but the amenity will be upgraded to a higher standard. For Mackenzie Street this could be done through widening the road corridor to include two lanes of traffic in each direction and providing new landscaping to enhance the streetscape. There may also be the opportunity to provide improved pedestrian and/or cyclist facilities.

As traffic continues to increase in the local area another stage of upgrades could be planned to allow the network to continue operating effectively. The intersection of Herries and Mackenzie Street is currently a roundabout configuration, which from visual inspection is operating efficiently. As traffic grows in the area especially with the additional volumes from Tourist Road and James Street the roundabout could be converted to a signalised intersection. This would facilitate a safer crossing opportunity for the pedestrians accessing the multiple medical and schooling facilities that are located in the area. Similarly the intersection of Mackenzie Street and Margaret Street could in the long-term benefit from being converted (to a signalised intersection) from the current sign controlled configuration.

7.2.2 Option A Estimate

Basic costing has been undertaken for the proposed works. Only the key construction elements have been considered and the values provided are for comparison only. Table 20 outlines the key elements of the required works and the associated costs.

Table 20: Option A Estimate

Intersection	Required Works	Estimated Cost
Mackenzie Street	• Adjusting signal phasing • Pavement widening • Relocation of power poles • Retaining wall construction • Footpath removal and replace • Pavement rehabilitation • Traffic management • Line marking • Drainage pit relocation • Kerb and channel removal and replace	**$1,000,000**
James Street	• Concrete island modification • Signage • Line marking	**$50,000**
Tourist Road	• Concrete island modification • Signage • Line marking	**$50,000**
	Total	**$1,100,000**

7.2.3 Option B

Similarly with Option A, Option B consists of individual components that integrate to form a complete local area traffic management plan. The intersection of James

Street and Curzon Street is the core component of Option B. Table 21 outlines the key components that form Option B.

Table 21: Option B Summary

Intersection	Proposed changes
Curzon Street	• Full signalisation • Introduce auxiliary right turn lanes on Cohoe Street east and west
James Street	• Restrict access to left in and left out only • Alternative route via Curzon Street
Tourist Road	• Restrict access to left in and left out only • Alternative access to city via Herries Street

Curzon Street is currently a sign controlled local street that connects to Cohoe Street and is located approximately 210 meters downstream of James Street. All movements from Curzon Street are made from the single approach lane.

Option B would see the Curzon Street intersection upgraded to include traffic signals and auxiliary turn lanes on Cohoe Street. Currently there are no turn lanes provided for access from Cohoe Street into Curzon Street although from observation there are a number of drivers who are already bypassing through Curzon Street. During peak hour vehicles that are struggling to find sufficient gaps to turn right out of James Street to head north are instead exiting left and then turning right onto Curzon Street. The traffic signals located downstream at Mackenzie Street provide additional gaps in the East bound traffic stream potentially making it a quicker route for those heading north.

Extensive works would be required to implement this upgrade, as currently there is no existing signal infrastructure or the required pavement width. The initial costs would be significant for items such as signal infrastructure, pavement rehabilitation, traffic control, footpaths, drainage infrastructure and the relocation of power poles. The general disturbance to the community throughout the construction period would also be substantial as it with most urban infrastructure projects.

As mentioned previously there is a road hierarchy in place for most regions and is available through the local council. Toowoomba Regional Council identifies Curzon Street as a local street and as such encouraging arterial traffic to use Curzon Street is likely to be met with strong resistance from residents. There are mitigating options available to encourage agreement with residents such as increasing safety through speed reduction, providing additional through lanes or landscaping to improve the streetscape. Increasing the road width would encroach towards resident's properties but it would also potentially provide easier and safer access for residents entering and leaving their properties, as the increase in through traffic is likely to reduce gaps for access.

It is standard practice to reduce the number of access points to highways in a bid to maintain free flow conditions. The road authorities might not favour implementing traffic signals at Curzon Street, as it is encouraging access to the highway. However, by upgrading Curzon Street there would be potential opportunities for other connecting streets such as Ipswich Street, Suffolk Street and John Street to have their access to Cohoe Street removed.

The next component involves access restriction at the intersection of James Street and Cohoe Street. As with Option A it is proposed that right turn out of James Street be restricted to left out only with the right turn being removed. Eventually when functionality of the right turn from Cohoe Street into James Street begins to decline consideration should be given to restricting the movement, allowing left in access only. Implementing traffic signals downstream at Curzon Street would provide a safe location for right turning traffic heading north from James Street. Road users would exit left from James Street and then make the right turn at Curzon Street. For traffic that is turning right from Cohoe Street into James Street the alternate route would be to turn right at the newly implemented signals at Curzon Street and then use the local network such as Crown and Burke Street. Figure 15 highlights in blue one of the possible alternate routes for access out of James Street.

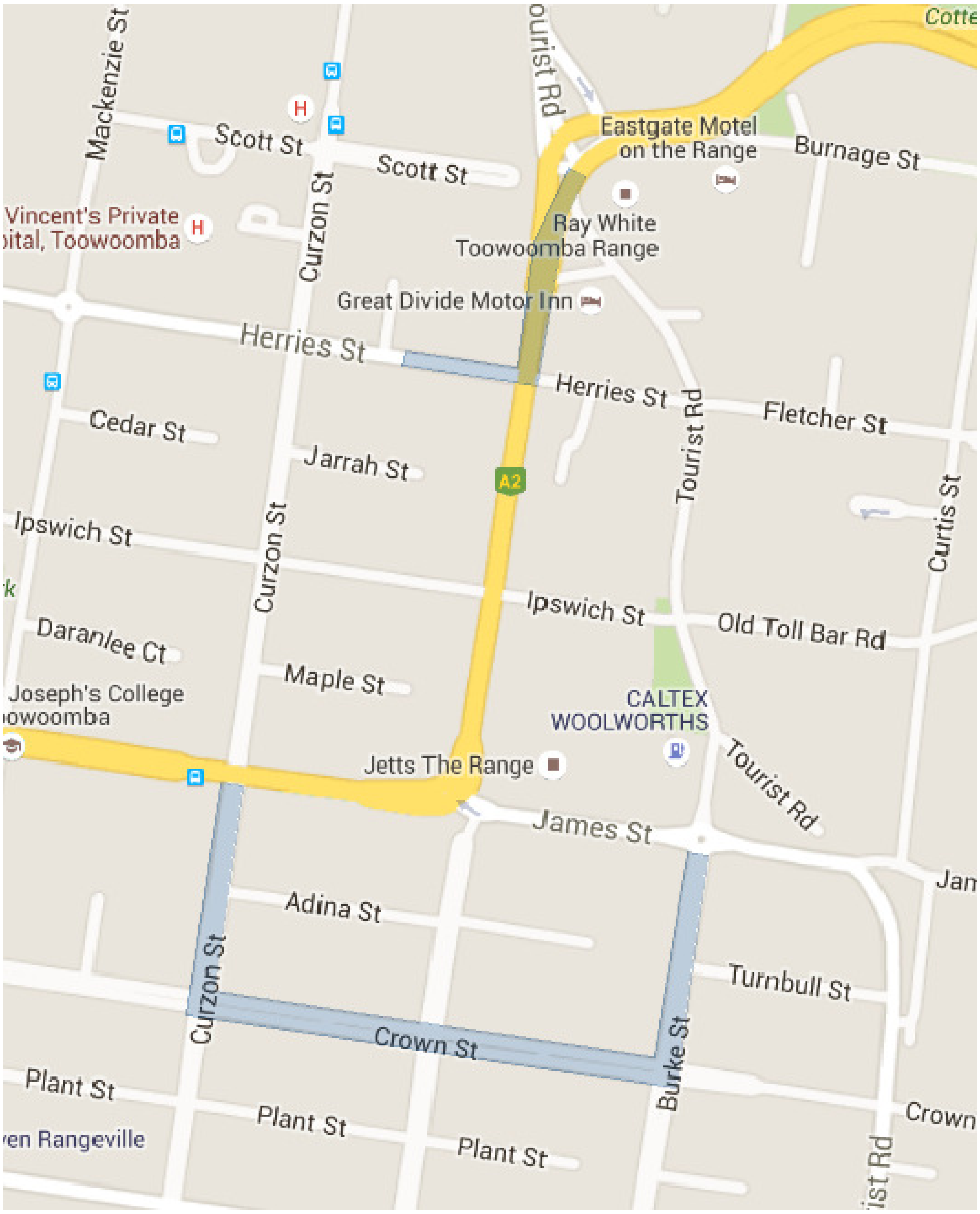


Figure 15: Alternative Route for Accessing James Street & Diverted Right Turn from Tourist Road to Herries Street (Option B) (Google Maps, 2015).

The final component that forms Option B is limiting access at the Tourist Road and Cohoe Street Intersection. Similarly with Option A it is recommended that the right turn from Cohoe Street into Tourist Road be restricted with left in access only. Traffic flows turning right would have the opportunity to do so at Herries Street (refer Figure 15). The movement at Herries Street is inherently safer due to the signalisation as motorists are not required to judge a safe gap for themselves reducing the opportunity for driver error. It is likely that motorists are already making the decision during peak hour to use Herries Street as alternate access to the city rather than queuing at Tourist Road. From visual inspection the sight distance at Tourist Road is restrictive with the intersection being located on the top of an upgrade and lighting infrastructure reducing the line of sight making Herries Street a more appealing location for turning. The appeal will only be increased with the planned signalisation.

It also recommended that the through and right movements from Tourist Road be restricted to left out only. For road users accessing the south-eastern side of Toowoomba via Tourist Road there is no direct alternate route. Although, once road users become aware of the safety issues with crossing a highway, they will usually seek an alternative route themselves. One such route would be via Curzon Street.

7.2.4 Option B Estimate

Basic costing has been undertaken for the proposed works. Only the key construction elements have been considered and the values provided are for comparison only. Table 22 outlines the key elements of the required works and the associated costs.

Table 22: Option B Estimate

Intersection	Required Works	Estimated Cost
Curzon Street	• Full traffic signal infrastructure (detector loops, signal arms and masts etc.) • Pavement widening • Relocation of power poles • Concrete islands • Footpath removal and replace • Pavement rehabilitation • Traffic management • Line marking • Drainage pit relocation • Kerb and channel removal and replace	**$1,200,000**
James Street	• Concrete modification • Signage • Line marking	**$50,000**
Tourist Road	• Concrete island modification • Signage • Line marking	**$50,000**
	Total	**$1,300,000**

7.2.5 Option C

As with both Option A and B, Option C also consists of multiple components that form the overall solution for the Cohoe Street Link. The intersection of Herries Street and Cohoe Street forms the basis for the proposed solution C. Table 23 outlines the key components that form Option C.

Table 23: Option C Summary

Intersection	Proposed changes
Herries Street	• Reinstate the through movement for Herries Street west • Re-introduces all access to Herries Street east • Fully signalize all legs • Possible introduction of an auxiliary right turn lane of Cohoe Street south
James Street	• Restrict access to left in and left out only • Alternative route via Herries Street
Tourist Road	• Restrict access to left in and left out only • Alternative access to city via Herries Street

The Herries Street intersection is currently sign controlled but a new development that is currently under construction on the North West corner includes altering the configuration to include traffic signals. The southbound traffic will not be impacted by the planned signalisation but access to and from east Herries Street will be restricted to left in and left out only.

Option C would see Herries Street re-configured back to a four way intersection with all legs controlled by traffic signals. Consideration would be given to constructing an auxiliary right turn lane on the southern leg of Cohoe Street to enable the safe right turn movement into Herries Street east. Constructing the right turn lane possibly could be avoided if an acceptable level of service could be maintained with a form of split phasing for the signals. Herries Street east would require basic line marking to define separate movements on the approach as from visual inspection there is currently adequate width for two lanes i.e. combined left and through and a right turn lane. Access from Herries Street West to Cohoe Street is currently left out only and this will remain in place with the development re-configuration although an additional left turn lane is being incorporated. This additional lane could be reconfigured to provide a combined through and right turn lane.

Overall minimal construction work would be required to re-configure the layout as the half of the traffic signal infrastructure will be already be in place and to current standard. Although the cost may be minimal the proposal will likely be met with strong opposition from community groups as was the case with the initial development application. Part of the original opposition was to the introduction of traffic signals on Cohoe Street as this is a highway with a large percentage of heavy vehicles. Traffic signals can cause significant delays to heavy vehicles as they are limited in their ability to gain momentum once slowed or stopped. Ultimately, safety is the priority along with providing the greatest benefit to the wider community.

Fully signalising and reinstating all movements to and from Herries Street East enables restrictions to be implemented at other locations such as Tourist Road and James Street. General connectivity for the local area will also be greatly improved with the provision of a safe crossing location for those on the western side of Cohoe Street wishing to access east Toowoomba, as currently the closest signalised crossing is located 860 meters downstream at Mackenzie Street.

Access restrictions at Tourist Road are the next component of solution C. It is proposed as with Options A and B that the right turn from Cohoe Street into Tourist Road be removed. Motorists wishing to turn right will continue to Herries Street (refer Figure 16) where the signals and auxiliary right turn lane provide a safe opportunity to make the right turn movement. It is also proposed that the through and right turn from Tourist Road be removed, allowing left out only. An alternative route could be sought following either Mackenzie Street or Curzon Street to the four way intersection at Herries Street allowing a safe and efficient crossing point to the east of Cohoe Street.

Similarly with Option A and B it is proposed that the right turn from Cohoe Street into James Street be removed when the movements capacity begins to decline. The right turn out of James Street is also recommended as being restricted to left out only. Those motorists wishing to head north on Cohoe Street to reach the northern area of Toowoomba could do so by following local network streets such as Tourist Road to reach the Herries Street intersection (refer Figure 16). Multiple alternate routes are available for motorists who are currently turning right into James Street from Cohoe Street including the Herries Street and Mackenzie Street intersections. Ultimately road users will chose their own alternative route that is best suited to their specific origin and destination. Removing the access to Cohoe Street from Ipswich Street could potentially increase safety and encourage better flow on the highway. This could form a part of the future program of works for the area when the need arises due to increased traffic volumes along Cohoe Street.

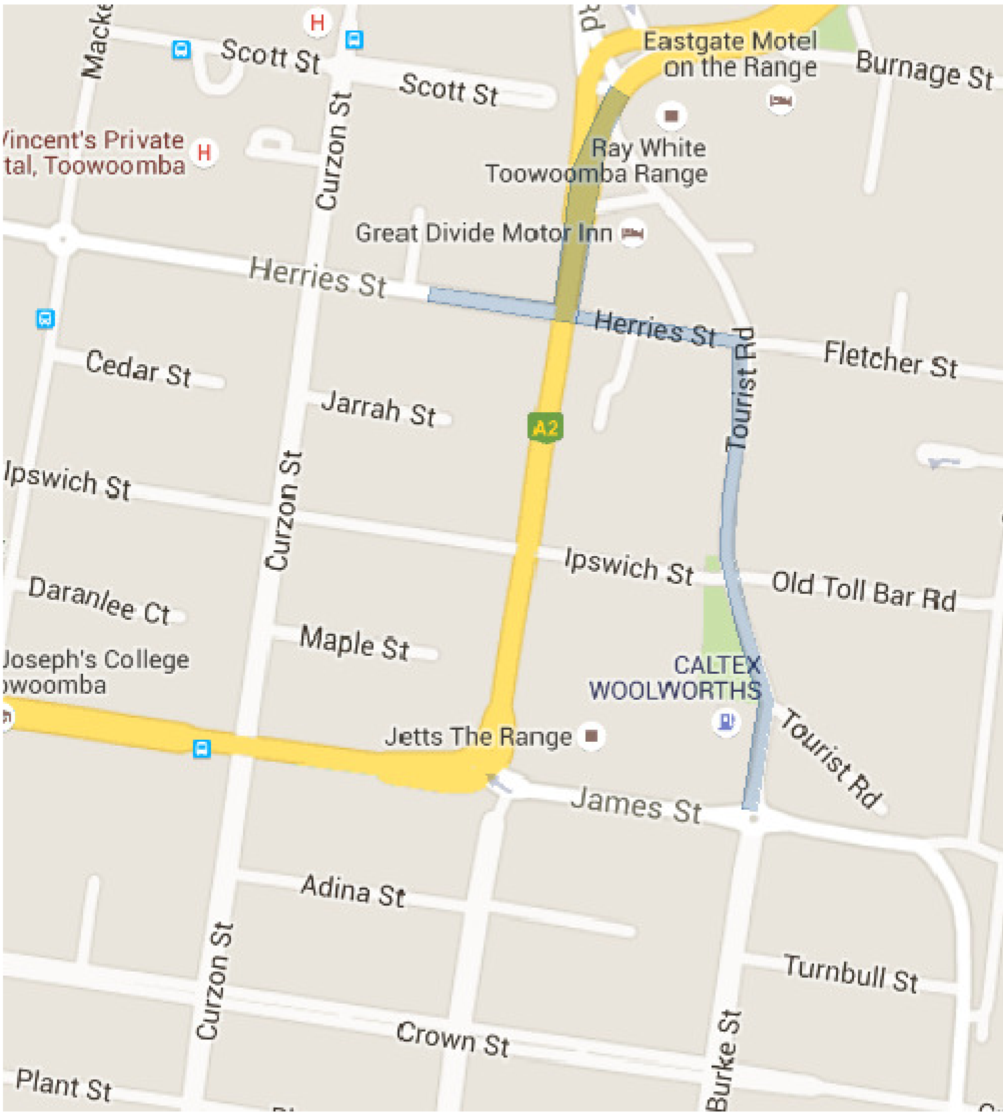


Figure 16: Alternative Routes via Herries Street (Option C) (Google Maps, 2015).

Within the road hierarchy Herries Street west is identified as a sub-arterial and Tourist Road is identified as a distributor. Herries Street east however is a local Street and as such community consultation with the residents would need to be undertaken to ensure that any concerns are identified. It may be found that although traffic would be increasing on Herries Street this would offset by the addition of a safe through movement across Cohoe Street providing an increase in connectivity for the residents of Herries Street east and the surrounds.

As mentioned in Option A, currently the intersection of Herries Street and Mackenzie Street is a roundabout. Provision may be required in the future to convert this to a signalised four-way intersection to allow capacity for the increasing traffic volumes. Pedestrians accessing the local school and medical facilities in the area would also benefit from the introduction of traffic signals as it would provide a safe crossing opportunity.

7.2.6 Option C Estimate

Simplified costing has been undertaken for the proposed works. Only the key construction elements have been considered and the values provided are for comparison only. Table 24 outlines the key elements of the required works and the associated costs.

Table 24: Option C Estimate

Intersection	Required Works	Estimated Cost
Herries Street	• Adjusting signal phasing • Signal infrastructure • Concrete island removal • Traffic management • Line marking	**$600,000**
James Street	• Concrete island modification • Signage • Line marking	**$50,000**
Tourist Road	• Concrete island modification • Signage • Line marking	**$50,000**
	Total	**$700,000**

7.3 Options Assessment

The key objectives of the project have been identified and will form the base criteria for assessing options A, B and C. The objectives are as follows:

- Improved transport efficiency- improved traffic flow on Cohoe Street
- Improved safety- does the solution improve known safety issues on the link or create new issues
- Social and environmental impacts- to what extent will the impact on the community be, regarding issues such as but not limited to, connectivity, streetscape and disruption during construction
- Cost effectiveness- does the option provide the best value for money for the wider community

Table 25 provides a summary for how each option scored against the predefined objectives.

Table 25: Options Assesment

Project Objectives	Option A	Option B	Option C
Improved Transport Efficiency	✓✓✓	✓	✓
Improved Safety	✓✓✓	✓✓	✓✓
Minimal social and environmental impacts	✓	✓	✓
Cost Effectiveness	✓	✓	✓✓✓

Table 26 details the scoring systems used to grade options A, B and C.

Table 26: Options Assessment Marking Scheme

✓	Fairly meets the objectives
✓✓	Effectively meets the objectives
✓✓✓	Exceptionally meets the objectives

The key advantages and disadvantages of each option have been summarised in Table 27 along with the comparative cost estimate.

Table 27: Options Key Advantages and Disadvantages

Option	Base Estimate	Key Advantages	Key Disadvantages
A	$1,100,000	• Builds upon existing infrastructure and highway access point • Already classified as a distributor • Increased safety for existing right turners • Improve intersection efficiency	• Sight distance issues, potentially costly to rectify
B	$1,300,000	• Potentially safer location than Mackenzie Street	• Impeding flow on Cohoe Street • Likely to face strong community opposition • Existing traffic signals 230 metres downstream • Currently classified as a local Street • Increase in stop-start noise • Lower speed environment that Mackenzie Street
C	$700,000	• Relatively minor works to implement • Improved connectivity	• Impeding flow on Cohoe Street

7.4 Recommendation

The options assessment has identified Option A, upgrading the intersection of Mackenzie and James Street as the preferred choice.

It is recommended that auxiliary turn lanes be introduced on Cohoe Street East and West along with the associated signal phasing to allow a green arrow for the right turn movements. In the initial implementation stages it is recommended that the right turn out of James Street be removed. The right and through movement from Tourist Road along with the right turn from the Warrego Highway into Tourist Road are also recommended as being removed. Advanced signage will be required at both James Street and Tourist Road to give motorist's sufficient warning of the changes ahead, allowing them time to seek an alternative route.

The key benefits for implementing Option A are as follows;

- The potential to increase the safety of an existing intersection by introducing turn lanes and investigating the known sight distance issues
- Potential to increase the efficiency of an existing intersection by altering the phasing and introducing turn lanes
- Encouraging flow along the road link by improving upon an existing signalised intersection rather than introducing a new stop point
- Potential to provide increased safety for pedestrians and cyclists
- Likely to receive wider community support as the intersection has existing issues that could be rectified

Detailed investigation of the option would be required to confirm its feasibility. As part of this process comprehensive costing and community consultation would need to be conducted.

Chapter 8: Recommendations and Conclusion

8.1 Conclusion

Alleviating traffic congestion is a common and often challenging task faced by Traffic Engineers and Road Authorities. The community has certain expectations around the functionality and safety of the road network. They expect a road network that provides safe and efficient connections to activities such as employment and social opportunities. The aim of this dissertation was to model Cohoe Street, Toowoomba using SIDRA Intersection to investigate the feasibility of optimising traffic flow on the link.

The results from modelling found that the intersection of Tourist Road and Cohoe Street has two movements that are at or nearing capacity with low levels of service being experienced. The intersection of James and Cohoe Street was also found to have similar issues. Research identified access control and signalisation to be common methods for improving over-capacity intersections as detailed by the Australian Austroads and the American Institute for Engineers.

Initial consideration was given to options such as introducing a roundabout or traffic signals at Tourist Road. With the large traffic volumes and high composition of heavy vehicles these options were not feasible and failed to meet the overarching objective of improved flow on Cohoe Street. It was through this initial exploration the need for a differing approach to the investigation was found. A local area traffic management plan was deemed more appropriate for the link rather than focusing on the individual intersections in isolation.

The resulting solution employs a combination of access control and improvement to an existing signalised intersection to form a complete plan for the area. It is recommended that the intersection of Mackenzie and James Street be upgraded to include auxiliary right turn lanes and the associated phasing for right turn movements. Introducing turn lanes not only enables access restrictions to be implemented at James Street but it also provides an opportunity for increased safety at the existing intersection.

As a part of the upgrade works increased provision for cyclists and pedestrians could be implemented along with improved sight distance and overall intersection efficiency.

Cohoe Street is a complex road link due to the locality, the traffic volume and composition and also the road classification. Providing a solution that maintains connectivity for those crossing Cohoe Street whilst maintaining free flow conditions on the highway is a challenging task. The recommendation outlined in this dissertation provides one such solution from a limitless list of possible options.

8.2 Recommendations and Further Work

Investigating the functionality of the major intersections along Cohoe Street has identified that congestion is an issue and the link will require upgrading at some point in the future. The greatest benefit is likely to come from upgrading the intersection of Mackenzie and James Street.

This dissertation has also highlighted the general importance of road network analysis, traffic modelling and broader network planning.

The key recommendations are as follows;

1. The proposed improvements be investigated in further detail. Specifically the flow on effect from implementing access restrictions.
2. Re-assess the current process for identifying which roads require upgrading. Cohoe Street is just one of many roads in the expansive network that is going un-noticed.
3. Employ traffic modelling as a cost effective technique for investigating road link capacity
4. Consider the wider implications when proposing upgrade works. Specifically the social implications which are often overlooked.

Further studies that could be undertaken include investigating the impacts of the second range crossing on the Warrego Highway. This would need to be undertaken once the bypass is completed so that real data could be gathered for the altered traffic composition and volumes. There are numerous other streets within the Toowoomba Regional Council that could be investigated such as Ruthven Street or West Street. Both would be challenging and beneficial to industry.

This dissertation could also be expanded upon with a future researcher confirming the results of the report using a different modelling technique such as micro-simulation. The proposed solution could be built upon to include more of the road network, providing a complete local area traffic management plan.

Chapter 9: References

Arshad Ali Amjad 2004, *Cost Benefit Analysis for Construction Projects,* IEP-SAC Journal 2004-2005.

Austroads 2013, *Guide to Traffic Management Part 3: Traffic Studies and Analysis*, Austroads Incorporated, viewed 15 April 2015, <https://www.onlinepublications.austroads.com.au/items/AGTM03-13/>.

Austroads 2013, *Guide to Traffic Management Part 5: Road Management*, Austroads Incorporated, viewed 10 May 2015, <https://www.onlinepublications.austroads.com.au/items/AGTM05-14/>.

Austroads 2013, *Guide to Traffic Management Part 8: Local Traffic Management*, Austroads Incorporated, viewed 20 August 2015, <https://www.onlinepublications.austroads.com.au/items/AGTM08-08/>.

Austroads 2013, *Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings*, Austroads Incorporated, viewed 11 May, <https://www.onlinepublications.austroads.com.au/items/AGTM06-13/>.

Austroads 2010, *Modelling of Signalised Intersections: Case Study (AP-R365/10)*, Austroads Incorporated, viewed April 3 2015, <https://www.onlinepublications.austroads.com.au/items/AP-R365-10/>.

Austroads, 2015, *Level of Service Metrics (AP-R475-15)*, Austroads Incorporated, viewed 15 April 2015, <https://www.onlinepublications.austroads.com.au/items/AP-R475-15/>

Austroads 2006, *The Use and Application of Microsimulation Traffic Models (AP-R286/06)*, Austroads Incorporated, viewed 10 May 2015, <https://www.onlinepublications.austroads.com.au/items/AP-R286-06/>.

Austroads 2015, *Guide to Road Design Part 2: Design Considerations*, Austroads Incorporated, viewed 1 June 2015, <https://www.onlinepublications.austroads.com.au/items/AGRD02-15/>.

Andrew Tarko, Shafiul Azam & Mike Inerowicz 2010, *Operational Performance of Alternative Types of Intersections – a Systematic Comparison for Indiana Conditions,* Purdue University, School of Civil Engineering, West Lafayette.

BTRE 2007, *Estimating Urban Traffic and Congestion Cost Trends for Australian Cities*, Bureau of Transport and Regional Economics

Douglas A. Ripley 2005, *Quantifying the Safety Benefits of Traffic Control Devices: Benefit-Cost Analysis of Traffic Sign Upgrades,* Iowa State University, USA.

ITE 1989, *A toolbox for Alleviating Traffic Congestion*, Institute of transportation Engineers, Washington DC, USA.

SIDRA Solutions 2012, *SIDRA Intersection User Guide*, Akcelik and Associates, Victoria, Australia

TRB 2010, *Highway capacity manual*, Transportation Research Board, National Research Council, Washington DC, USA.

Toowoomba Regional Council 2010, *Transport Strategy Proposals,* Toowoomba Regional Council, viewed 8 September 2015, http://toowoombarc.qld.gov.au/cbdparking/documents/19784/>.

Queensland Department of Transport and Main Roads (QDTMR) 2004, *Road Planning and Design Manual, Chapter 5: Traffic Parameters and Human Factors*, Queensland Department of Main Roads, viewed 15 April 2015, <http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Road-planning-and-design-manual.aspx

Queensland Department of Transport and Main Roads (QDTMR) 2009, *Road Planning and Design Manual, Chapter 4A: Unsignalised and Signalised Intersections* Queensland Department of Main Roads, viewed 15 April 2015, < http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Road-planning-and-design-manual.aspx/>.

Queensland Department of Transport and Main Roads (QDTMR) 2014a, 'Chartview Database,' Customer Services, Safety and Regulation Division, Brisbane Australia.

Queensland Department of Transport and Main Roads (QDTMR) 2014b, 'Digital Video Roads (DVR)' DVR files.

Queensland Department of Transport and Main Roads (QDTMR) 2014c,'Traffic Analysis Report', Traffic Analysis and Reporting System (TARDS) database, Toowoomba, Australia.

Appendix A- Project Specification

University of Southern Queensland

FACULTY OF ENGINEERING AND SURVEYING

PROJECT SPECIFCATION
ENG4111 / 4112 Research Project

FOR: Kelly Pearson (0061002991)

TOPIC: **Feasibility of Improved Traffic Flow on Cohoe Street, Toowoomba by Intersection Improvements**

SUPERVISORS: USQ - Professor Ron Ayers

Work – Adam Currie, Department of Transport and Main Roads

PROJECT AIM: This project seeks to model Cohoe Street, Toowoomba in SIDRA Intersection to investigate the feasibility of optimising traffic flows between the Top of the Range and James Street.

PROGRAM: Issue B; 17th October 2015

1. Research background information, from both Australia and overseas, regarding:
   - Intersection modelling
   - Level of Service (LOS) standards for intersections
   - Methods for improving over capacity intersections

2. Gather the required traffic data (counts and growth projections) for the selected intersections and any other relevant planning proposals that impact the functionality of Cohoe Street. Draft basic layouts of the intersections and the arterial road. Calculate traffic data for future cases using traffic growth projections.

3. Develop a model in SIDRA Intersection containing all of the intersections so they can be analysed individually and potentially as a network if required. Adopt standard SIDRA parameters for first pass of analysis.

4. Validate the model by comparing outputs of average delay with data collected from video footage of the intersections and calibrate if necessary.

5. Use the model to predict traffic flows and performance of Cohoe Street under future predicted traffic flows, and consider strategies to optimise flows.

6. Depending on the outcome of the analysis, re-model in SIDRA to develop improved layouts for intersections, optimising network cohesion and efficiency.

5. Write a dissertation on the project in the required format.

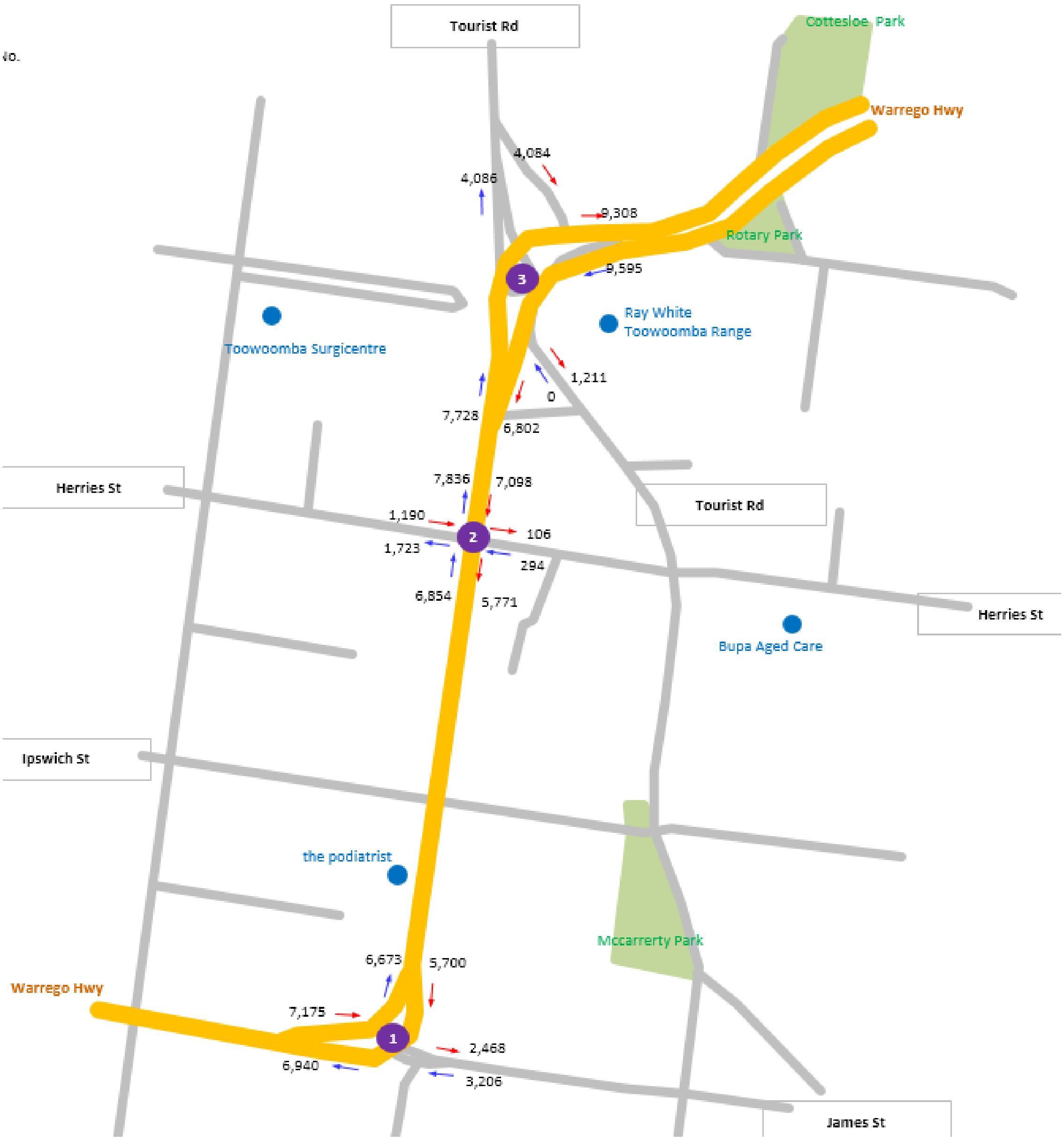
AS TIME PERMITS:

AGREED:

Student: Kelly Pearson Supervisor: RAyers
Date: 17 / 10 / 2015 Date: 20 / 10 / 15

Appendix B- Traffic Counts

B.1 Cohoe Street Flow Diagram (12 hours volumes)



B.2 Tourist Road- 12 Hour Totals

Approach			Warrego Hwy					Tourist Rd					Warrego Hwy					Tourist Rd					Grand Total
Time Period			Lights	Rigids	Artics	Road Train	Total	Lights	Rigids	Artics	Road Train	Total	Lights	Rigids	Artics	Road Train	Total	Lights	Rigids	Artics	Road Train	Total	
6:00	to	7:00	344	29	26	27	**426**	0	0	0	0	**0**	527	34	43	17	**621**	167	3	0	0	**170**	**1,217**
6:15	to	7:15	375	33	29	28	**465**	0	0	0	0	**0**	573	41	40	18	**672**	191	6	0	0	**197**	**1,334**
6:30	to	7:30	397	36	27	24	**484**	0	0	0	0	**0**	639	43	43	19	**744**	207	11	0	0	**218**	**1,446**
6:45	to	7:45	410	42	28	25	**505**	0	0	0	0	**0**	798	51	34	14	**897**	218	11	0	0	**229**	**1,631**
7:00	to	8:00	447	37	32	27	**543**	0	0	0	0	**0**	976	52	23	22	**1,073**	229	12	1	0	**242**	**1,858**
7:15	to	8:15	518	39	36	29	**622**	0	0	0	0	**0**	1,110	57	28	23	**1,218**	240	12	4	1	**257**	**2,097**
7:30	to	8:30	528	38	37	34	**637**	0	0	0	0	**0**	1,188	54	33	26	**1,301**	280	12	5	1	**298**	**2,236**
7:45	to	8:45	531	41	38	33	**643**	0	0	0	0	**0**	1,143	48	33	33	**1,257**	294	15	5	2	**316**	**2,216**
8:00	to	9:00	507	39	35	38	**619**	0	0	0	0	**0**	1,015	54	40	36	**1,145**	333	16	4	2	**355**	**2,119**
8:15	to	9:15	453	44	36	39	**572**	0	0	0	0	**0**	930	51	39	36	**1,056**	337	16	1	1	**355**	**1,983**
8:30	to	9:30	438	53	40	37	**568**	0	0	0	0	**0**	869	56	32	39	**996**	308	14	0	1	**323**	**1,887**
8:45	to	9:45	400	51	38	46	**535**	0	0	0	0	**0**	812	57	34	39	**942**	294	12	1	0	**307**	**1,784**
9:00	to	10:00	393	52	37	39	**521**	0	0	0	0	**0**	820	50	41	34	**945**	261	11	2	0	**274**	**1,740**
9:15	to	10:15	397	47	35	35	**514**	0	0	0	0	**0**	781	54	42	28	**905**	261	9	2	0	**272**	**1,691**
9:30	to	10:30	396	48	33	33	**510**	0	0	0	0	**0**	750	54	38	32	**874**	272	7	3	0	**282**	**1,666**
9:45	to	10:45	408	50	35	29	**522**	0	0	0	0	**0**	714	55	34	33	**836**	287	5	2	0	**294**	**1,652**
10:00	to	11:00	414	55	41	29	**539**	0	0	0	0	**0**	643	57	25	38	**763**	302	6	1	0	**309**	**1,611**
10:15	to	11:15	402	51	40	34	**527**	0	0	0	0	**0**	593	55	25	47	**720**	293	10	1	0	**304**	**1,551**
10:30	to	11:30	412	46	40	42	**540**	0	0	0	0	**0**	551	50	29	42	**672**	291	10	0	0	**301**	**1,513**
10:45	to	11:45	451	42	36	43	**572**	0	0	0	0	**0**	562	55	33	43	**693**	287	9	0	0	**296**	**1,561**
11:00	to	12:00	468	39	28	50	**585**	0	0	0	0	**0**	564	53	32	41	**690**	280	10	1	0	**291**	**1,566**
11:15	to	12:15	462	43	27	51	**583**	0	0	0	0	**0**	570	50	31	38	**689**	272	13	1	0	**286**	**1,558**
11:30	to	12:30	477	43	30	52	**602**	0	0	0	0	**0**	548	42	36	40	**666**	253	18	1	0	**272**	**1,540**

11:45	to	12:45	470	46	28	50	**594**	0	0	0	0	**0**	531	37	35	37	**640**	257	23	1	0	**281**	**1,515**
12:00	to	13:00	482	47	33	47	**609**	0	0	0	0	**0**	527	36	40	31	**634**	261	24	0	0	**285**	**1,528**
12:15	to	13:15	505	64	31	41	**641**	0	0	0	0	**0**	517	40	41	34	**632**	279	20	0	0	**299**	**1,572**
12:30	to	13:30	509	69	24	34	**636**	0	0	0	0	**0**	528	49	36	32	**645**	297	14	1	0	**312**	**1,593**
12:45	to	13:45	511	65	30	32	**638**	0	0	0	0	**0**	507	51	38	35	**631**	277	8	1	0	**286**	**1,555**
13:00	to	14:00	517	63	27	29	**636**	0	0	0	0	**0**	496	57	32	46	**631**	268	6	1	0	**275**	**1,542**
13:15	to	14:15	554	43	34	30	**661**	0	0	0	0	**0**	488	54	36	41	**619**	290	9	1	0	**300**	**1,580**
13:30	to	14:30	581	37	38	29	**685**	0	0	0	0	**0**	513	50	42	39	**644**	314	11	0	0	**325**	**1,654**
13:45	to	14:45	623	37	38	29	**727**	0	0	0	0	**0**	527	54	43	44	**668**	354	12	0	0	**366**	**1,761**
14:00	to	15:00	641	43	38	34	**756**	0	0	0	0	**0**	546	52	50	35	**683**	393	14	1	0	**408**	**1,847**
14:15	to	15:15	678	43	32	35	**788**	0	0	0	0	**0**	586	52	45	41	**724**	419	11	1	0	**431**	**1,943**
14:30	to	15:30	678	38	27	32	**775**	0	0	0	0	**0**	619	50	41	47	**757**	473	10	1	0	**484**	**2,016**
14:45	to	15:45	712	41	28	30	**811**	0	0	0	0	**0**	649	40	41	42	**772**	517	13	1	0	**531**	**2,114**
15:00	to	16:00	743	36	29	31	**839**	0	0	0	0	**0**	690	35	35	43	**803**	516	11	1	0	**528**	**2,170**
15:15	to	16:15	766	31	31	33	**861**	0	0	0	0	**0**	689	34	33	33	**789**	528	10	1	0	**539**	**2,189**
15:30	to	16:30	797	34	34	35	**900**	0	0	0	0	**0**	656	33	32	27	**748**	505	12	1	0	**518**	**2,166**
15:45	to	16:45	795	29	26	38	**888**	0	0	0	0	**0**	670	40	35	24	**769**	478	9	1	0	**488**	**2,145**
16:00	to	17:00	777	21	27	29	**854**	0	0	0	0	**0**	684	39	41	30	**794**	500	7	0	0	**507**	**2,155**
16:15	to	17:15	769	26	24	28	**847**	0	0	0	0	**0**	724	37	42	33	**836**	494	5	0	0	**499**	**2,182**
16:30	to	17:30	773	23	21	28	**845**	0	0	0	0	**0**	778	38	40	34	**890**	482	2	0	0	**484**	**2,219**
16:45	to	17:45	740	23	27	32	**822**	0	0	0	0	**0**	774	26	34	39	**873**	489	1	0	0	**490**	**2,185**
17:00	to	18:00	698	34	29	40	**801**	0	0	0	0	**0**	738	22	22	31	**813**	439	1	0	0	**440**	**2,054**
12hr Totals			**6,431**	**495**	**382**	**420**	**7,728**	**0**	**0**	**0**	**0**	**0**	**8,226**	**541**	**424**	**404**	**9,595**	**3,949**	**121**	**12**	**2**	**4,084**	**21,407**

B.3 Herries Street- 12 Hour Totals

Approach	Warrego Hwy					Herries St					Warrego Hwy					Herries St					Grand Total
Time Period	Lights	Rigids	Artics	Road Train	Total	Lights	Rigids	Artics	Road Train	Total	Lights	Rigids	Artics	Road Train	Total	Lights	Rigids	Artics	Road Train	Total	
6:00 to 7:00	293	17	24	34	**368**	11	1	0	0	**12**	375	30	36	20	**461**	30	0	1	0	**31**	**872**
6:15 to 7:15	332	26	26	31	**415**	16	2	0	0	**18**	405	36	30	24	**495**	35	1	1	0	**37**	**965**
6:30 to 7:30	356	31	23	26	**436**	17	1	0	0	**18**	428	40	31	23	**522**	37	3	1	0	**41**	**1,017**
6:45 to 7:45	388	35	28	26	**477**	22	1	0	0	**23**	524	38	29	19	**610**	40	5	1	0	**46**	**1,156**
7:00 to 8:00	416	30	32	31	**509**	29	1	0	0	**30**	643	42	19	20	**724**	46	5	0	0	**51**	**1,314**
7:15 to 8:15	493	29	39	33	**594**	28	0	0	0	**28**	768	46	23	24	**861**	52	4	1	0	**57**	**1,540**
7:30 to 8:30	507	29	41	34	**611**	29	0	0	0	**29**	814	50	31	25	**920**	57	4	1	0	**62**	**1,622**
7:45 to 8:45	518	33	46	32	**629**	26	0	0	0	**26**	816	49	33	29	**927**	64	2	1	0	**67**	**1,649**
8:00 to 9:00	496	30	41	33	**600**	25	0	0	0	**25**	757	50	40	35	**882**	67	4	1	0	**72**	**1,579**
8:15 to 9:15	443	37	38	36	**554**	23	0	0	0	**23**	671	49	40	28	**788**	67	6	1	0	**74**	**1,439**
8:30 to 9:30	416	38	44	37	**535**	27	0	0	0	**27**	644	48	34	32	**758**	69	7	2	0	**78**	**1,398**
8:45 to 9:45	373	39	41	44	**497**	28	0	0	0	**28**	576	47	32	37	**692**	63	8	2	0	**73**	**1,290**
9:00 to 10:00	366	43	43	38	**490**	31	0	0	0	**31**	588	46	37	34	**705**	53	7	2	0	**62**	**1,288**
9:15 to 10:15	349	39	41	31	**460**	30	0	0	0	**30**	556	45	40	31	**672**	53	6	1	0	**60**	**1,222**
9:30 to 10:30	358	43	42	29	**472**	26	0	0	0	**26**	530	46	36	35	**647**	56	5	1	0	**62**	**1,207**
9:45 to 10:45	354	36	42	24	**456**	25	0	0	0	**25**	512	48	34	32	**626**	63	7	2	0	**72**	**1,179**
10:00 to 11:00	361	42	47	27	**477**	19	0	1	0	**20**	472	48	30	36	**586**	66	7	2	0	**75**	**1,158**
10:15 to 11:15	361	36	48	28	**473**	21	1	1	0	**23**	439	42	29	44	**554**	69	6	2	0	**77**	**1,127**
10:30 to 11:30	357	37	46	35	**475**	20	1	1	0	**22**	410	40	32	36	**518**	72	5	2	0	**79**	**1,094**
10:45 to 11:45	410	43	43	35	**531**	18	1	1	0	**20**	418	46	34	39	**537**	70	2	1	0	**73**	**1,161**
11:00 to 12:00	428	39	39	41	**547**	15	1	0	0	**16**	414	41	29	35	**519**	74	2	1	0	**77**	**1,159**
11:15 to 12:15	412	42	38	42	**534**	15	0	0	0	**15**	413	46	31	32	**522**	71	3	1	0	**75**	**1,146**
11:30 to 12:30	429	38	38	47	**552**	15	1	0	0	**16**	422	43	34	37	**536**	70	5	0	0	**75**	**1,179**

11:45	to	12:45	419	37	37	46	**539**	19	1	0	0	**20**	424	36	33	37	**530**	83	5	0	0	**88**	**1,177**
12:00	to	13:00	423	38	37	43	**541**	23	1	0	0	**24**	377	38	40	33	**488**	86	6	0	0	**92**	**1,145**
12:15	to	13:15	450	40	34	40	**564**	24	1	0	0	**25**	371	36	41	36	**484**	94	6	0	0	**100**	**1,173**
12:30	to	13:30	444	44	29	31	**548**	31	1	0	0	**32**	358	38	39	32	**467**	98	5	0	0	**103**	**1,150**
12:45	to	13:45	453	42	30	31	**556**	26	1	0	0	**27**	338	40	40	32	**450**	94	5	1	0	**100**	**1,133**
13:00	to	14:00	465	41	29	27	**562**	24	1	0	0	**25**	363	41	33	43	**480**	97	4	1	0	**102**	**1,169**
13:15	to	14:15	486	37	32	31	**586**	28	2	0	0	**30**	364	46	32	39	**481**	105	3	1	0	**109**	**1,206**
13:30	to	14:30	514	31	36	27	**608**	22	2	0	0	**24**	379	44	42	38	**503**	106	6	1	0	**113**	**1,248**
13:45	to	14:45	524	31	40	33	**628**	29	2	0	0	**31**	383	47	43	40	**513**	115	6	1	0	**122**	**1,294**
14:00	to	15:00	538	38	37	35	**648**	31	2	0	0	**33**	375	50	51	30	**506**	118	6	2	0	**126**	**1,313**
14:15	to	15:15	572	37	39	38	**686**	29	1	0	0	**30**	386	43	54	33	**516**	128	7	2	0	**137**	**1,369**
14:30	to	15:30	563	36	35	34	**668**	30	0	0	0	**30**	418	45	45	37	**545**	141	4	2	0	**147**	**1,390**
14:45	to	15:45	595	39	35	27	**696**	25	0	0	0	**25**	439	35	47	35	**556**	163	7	1	0	**171**	**1,448**
15:00	to	16:00	614	31	39	29	**713**	29	0	0	0	**29**	489	28	38	37	**592**	173	9	0	0	**182**	**1,516**
15:15	to	16:15	643	28	35	25	**731**	30	0	0	0	**30**	513	32	30	33	**608**	161	8	0	0	**169**	**1,538**
15:30	to	16:30	677	30	36	33	**776**	30	0	0	0	**30**	473	26	31	28	**558**	158	7	0	0	**165**	**1,529**
15:45	to	16:45	670	26	29	35	**760**	34	0	0	0	**34**	473	34	30	27	**564**	138	4	0	0	**142**	**1,500**
16:00	to	17:00	652	19	29	32	**732**	26	0	0	0	**26**	463	39	48	22	**572**	139	2	0	0	**141**	**1,471**
16:15	to	17:15	625	23	26	32	**706**	30	0	0	0	**30**	480	38	51	23	**592**	166	3	0	0	**169**	**1,497**
16:30	to	17:30	625	24	24	27	**700**	27	0	0	0	**27**	525	42	46	25	**638**	174	3	0	0	**177**	**1,542**
16:45	to	17:45	596	22	28	34	**680**	20	0	0	0	**20**	522	33	44	26	**625**	179	3	0	0	**182**	**1,507**
17:00	to	18:00	566	31	31	39	**667**	22	1	0	0	**23**	500	27	25	31	**583**	177	2	0	0	**179**	**1,452**
12hr Totals			**5,618**	**399**	**428**	**409**	**6,854**	**285**	**8**	**1**	**0**	**294**	**5,816**	**480**	**426**	**376**	**7,098**	**1,126**	**54**	**10**	**0**	**1,190**	**15,436**

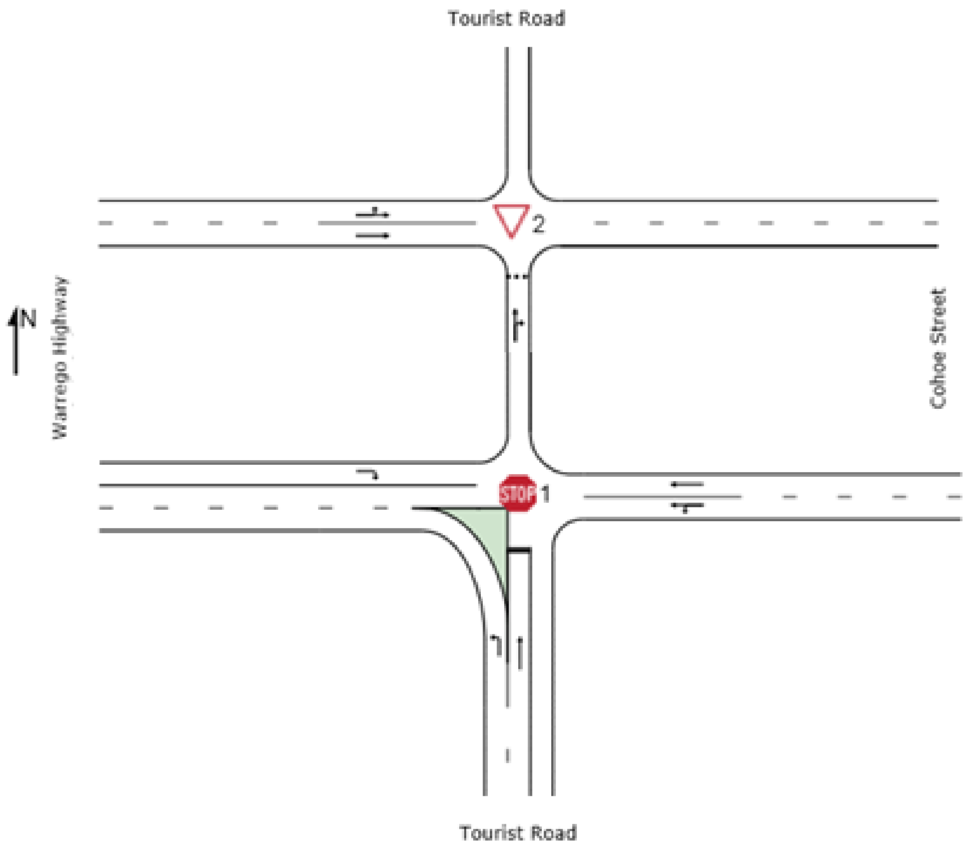
B.4 James Street- 12 Hour Totals

Approach						Jemes St					Warrego Hwy					Warrego Hwy					Grand Total
Time Period						Lights	Rigids	Artics	Road Train	Total	Lights	Rigids	Artics	Road Train	Total	Lights	Rigids	Artics	Road Train	Total	
6:00 to 7:00						115	1	0	2	**118**	294	34	41	25	**394**	280	26	32	20	**358**	**870**
6:15 to 7:15						146	1	0	2	**149**	310	32	39	25	**406**	275	33	30	24	**362**	**917**
6:30 to 7:30						177	1	0	0	**178**	328	31	41	24	**424**	290	37	29	20	**376**	**978**
6:45 to 7:45						204	1	1	0	**206**	378	30	33	20	**461**	307	43	27	23	**400**	**1,067**
7:00 to 8:00						263	3	2	0	**268**	439	29	25	17	**510**	337	41	34	29	**441**	**1,219**
7:15 to 8:15						366	3	3	0	**372**	498	33	26	24	**581**	385	38	38	31	**492**	**1,445**
7:30 to 8:30						416	3	4	0	**423**	522	38	31	25	**616**	392	37	40	34	**503**	**1,542**
7:45 to 8:45						424	7	4	0	**435**	531	39	30	32	**632**	407	37	45	34	**523**	**1,590**
8:00 to 9:00						390	7	3	0	**400**	500	41	34	39	**614**	391	35	40	39	**505**	**1,519**
8:15 to 9:15						317	6	2	0	**325**	477	43	32	31	**583**	375	45	43	39	**502**	**1,410**
8:30 to 9:30						273	9	1	0	**283**	460	37	28	37	**562**	376	46	47	39	**508**	**1,353**
8:45 to 9:45						254	7	0	0	**261**	424	37	28	38	**527**	361	49	41	50	**501**	**1,289**
9:00 to 10:00						248	5	0	0	**253**	461	35	33	36	**565**	373	48	39	42	**502**	**1,320**
9:15 to 10:15						237	9	1	0	**247**	445	33	37	33	**548**	386	42	34	38	**500**	**1,295**
9:30 to 10:30						235	6	1	0	**242**	440	39	34	34	**547**	393	48	30	36	**507**	**1,296**
9:45 to 10:45						233	6	1	0	**240**	429	38	29	36	**532**	393	42	34	30	**499**	**1,271**
10:00 to 11:00						237	8	2	0	**247**	385	39	26	42	**492**	393	45	40	30	**508**	**1,247**
10:15 to 11:15						232	5	1	0	**238**	362	35	25	51	**473**	401	41	40	34	**516**	**1,227**
10:30 to 11:30						235	6	1	0	**242**	337	34	26	47	**444**	418	38	40	40	**536**	**1,222**
10:45 to 11:45						258	4	1	0	**263**	339	36	37	45	**457**	454	42	37	40	**573**	**1,293**
11:00 to 12:00						259	4	0	0	**263**	340	34	32	38	**444**	480	42	31	46	**599**	**1,306**
11:15 to 12:15						260	4	0	0	**264**	331	38	33	35	**437**	468	45	31	48	**592**	**1,293**
11:30 to 12:30						259	3	0	0	**262**	336	30	37	39	**442**	481	41	35	50	**607**	**1,311**
11:45 to 12:45						246	4	0	0	**250**	327	26	33	39	**425**	484	43	33	50	**610**	**1,285**

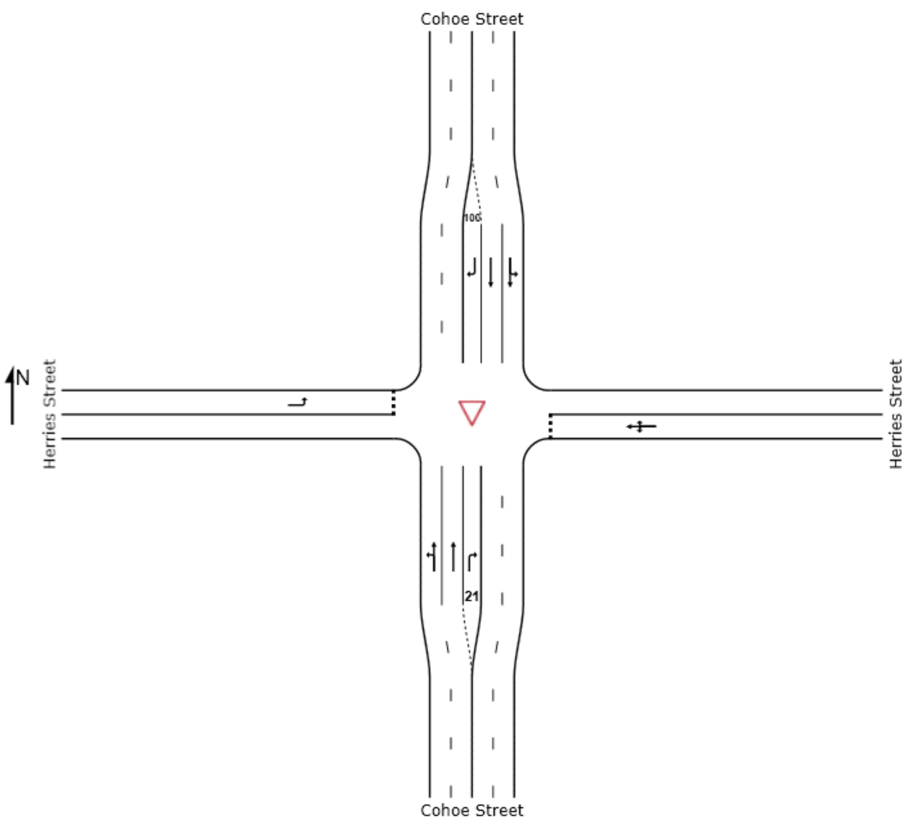
12:00 to 13:00						234	2	1	0	**237**	291	25	41	37	**394**	488	43	36	47	**614**	**1,245**
12:15 to 13:15						249	3	1	0	**253**	293	24	43	40	**400**	523	44	33	41	**641**	**1,294**
12:30 to 13:30						237	4	1	0	**242**	285	27	40	36	**388**	501	47	26	34	**608**	**1,238**
12:45 to 13:45						252	3	1	0	**256**	278	36	36	40	**390**	508	44	27	32	**611**	**1,257**
13:00 to 14:00						261	3	0	0	**264**	293	38	28	50	**409**	498	42	26	30	**596**	**1,269**
13:15 to 14:15						255	2	0	0	**257**	289	41	24	47	**401**	494	38	31	31	**594**	**1,252**
13:30 to 14:30						278	3	0	0	**281**	293	40	34	47	**414**	527	33	35	33	**628**	**1,323**
13:45 to 14:45						264	4	0	0	**268**	296	39	36	51	**422**	538	31	40	31	**640**	**1,330**
14:00 to 15:00						294	4	0	0	**298**	298	40	45	41	**424**	569	39	39	35	**682**	**1,404**
14:15 to 15:15						320	5	0	0	**325**	314	35	49	44	**442**	589	36	36	36	**697**	**1,464**
14:30 to 15:30						331	5	0	0	**336**	340	38	42	46	**466**	627	35	34	28	**724**	**1,526**
14:45 to 15:45						339	4	1	0	**344**	359	29	46	40	**474**	667	40	32	27	**766**	**1,584**
15:00 to 16:00						329	4	1	0	**334**	396	24	39	41	**500**	692	32	35	27	**786**	**1,620**
15:15 to 16:15						307	5	1	0	**313**	407	28	31	37	**503**	728	31	32	31	**822**	**1,638**
15:30 to 16:30						304	5	1	0	**310**	379	23	29	33	**464**	718	31	31	36	**816**	**1,590**
15:45 to 16:45						294	5	0	0	**299**	370	27	31	30	**458**	722	24	27	38	**811**	**1,568**
16:00 to 17:00						271	5	0	0	**276**	365	30	39	34	**468**	718	19	26	31	**794**	**1,538**
16:15 to 17:15						285	3	0	0	**288**	381	28	46	37	**492**	731	22	26	28	**807**	**1,587**
16:30 to 17:30						276	1	0	0	**277**	416	30	44	40	**530**	747	24	24	28	**823**	**1,630**
16:45 to 17:45						278	1	0	0	**279**	421	23	41	40	**525**	725	24	30	31	**810**	**1,614**
17:00 to 18:00						247	1	0	0	**248**	399	21	28	38	**486**	687	33	30	40	**790**	**1,524**
12hr Totals						**3,148**	**47**	**9**	**2**	**3,206**	**4,461**	**390**	**411**	**438**	**5,700**	**5,906**	**445**	**408**	**416**	**7,175**	**16,081**

Appendix C- SIDRA Layouts

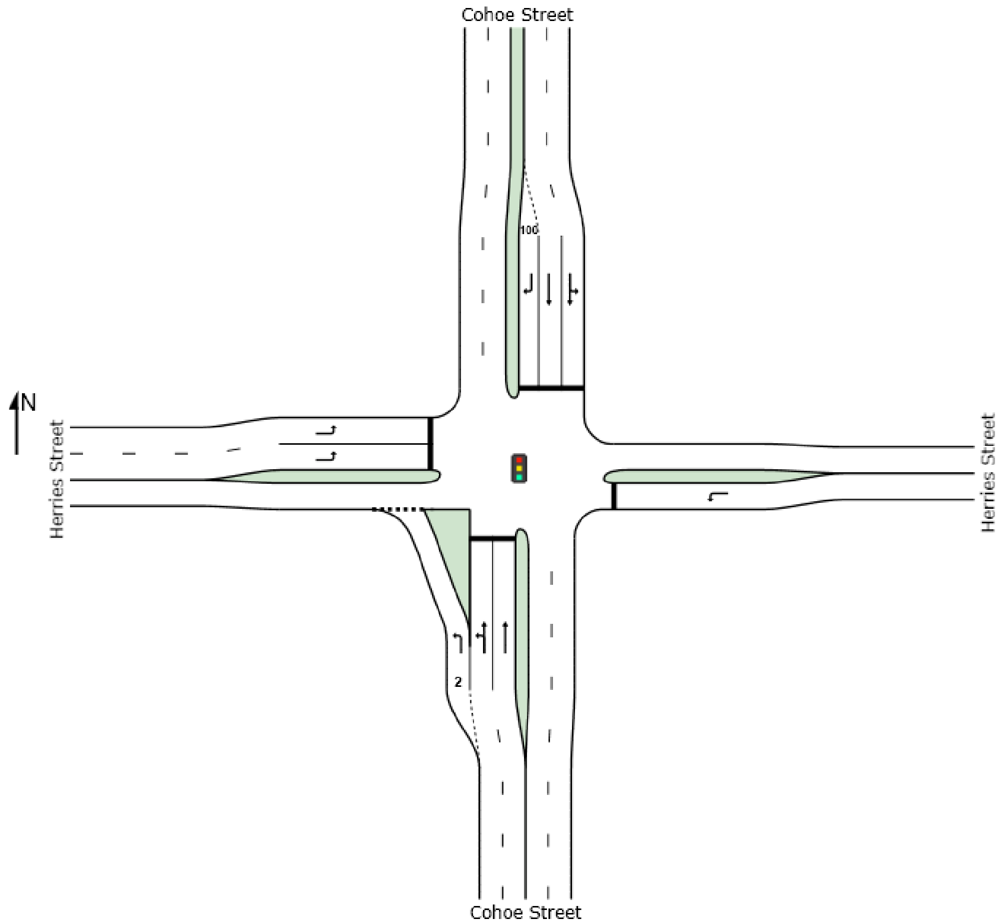
C.1 Tourist Road



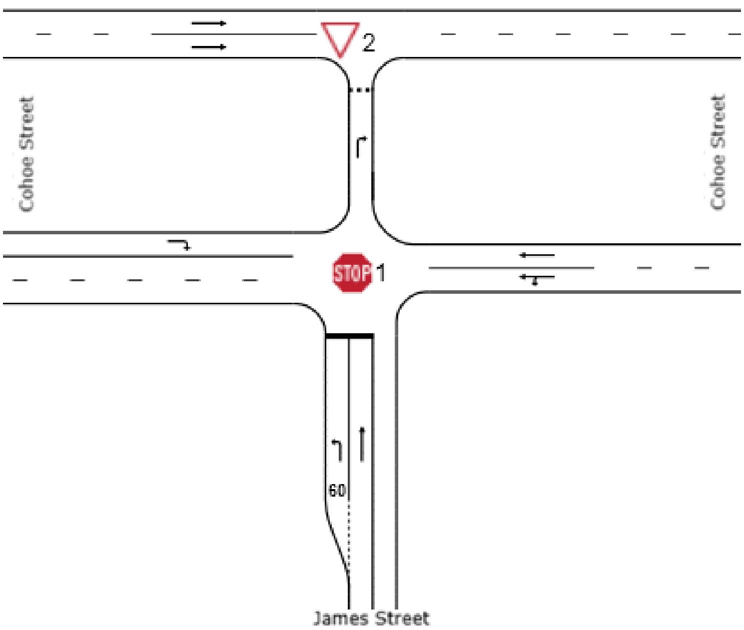
C.2 Herries Street- Current Layout



C.3 Herries Street- Planned Layout



C.4 James Street



Appendix D- SIDRA Output Summaries

D.1 Tourist Road- Current Year (2015), no Bunching

MOVEMENT SUMMARY

Site: Stop 3-way Stage 1 (Minor Road) L

Staged crossing Stage 1 (Minor Road) at three-way intersection with 5-lane major road. Major road turn lane is treated as a full-length lane.
Stop (Two-Way)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Tourist Road											
1	L2	366	0.6	0.198	5.6	LOS A	0.0	0.0	0.00	0.53	54.9
2	T1	143	0.0	0.609	33.4	LOS D	3.0	20.7	0.91	1.15	24.9
Approach		509	0.4	0.609	13.4	LOS B	3.0	20.7	0.26	0.70	45.8
East: Cohoe Street											
4	L2	111	0.0	0.242	5.5	LOS A	0.0	0.0	0.00	0.15	57.0
5	T1	779	10.0	0.242	0.0	LOS A	0.0	0.0	0.00	0.06	59.3
Approach		889	8.8	0.242	0.7	NA	0.0	0.0	0.00	0.07	59.0
West: Warrego Highway											
12	R2	265	1.6	0.547	16.6	LOS C	3.1	21.8	0.81	1.07	46.1
Approach		265	1.6	0.547	16.6	NA	3.1	21.8	0.81	1.07	46.1
All Vehicles		1664	5.1	0.609	7.1	NA	3.1	21.8	0.21	0.43	52.4

MOVEMENT SUMMARY

Site: Stop 3-way Stage 2 (Median) L

Staged crossing Stage 2 (Median) at three-way intersection with 5-lane major road.
Give-way behaviour assumed at Stage 2.
Giveway / Yield (Two-Way)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Median Storage Area											
2	T1	111	0.0	0.198	4.4	LOS A	0.7	4.8	0.56	0.73	49.9
3	R2	33	0.0	0.198	5.4	LOS A	0.7	4.8	0.56	0.73	49.1
Approach		143	0.0	0.198	4.6	LOS A	0.7	4.8	0.56	0.73	49.7
West: Warrego Highway											
10	L2	62	1.7	0.192	5.6	LOS A	0.0	0.0	0.00	0.11	57.2
11	T1	609	18.5	0.192	0.0	LOS A	0.0	0.0	0.00	0.05	59.4
Approach		672	16.9	0.192	0.5	NA	0.0	0.0	0.00	0.06	59.2
All Vehicles		815	14.0	0.198	1.2	NA	0.7	4.8	0.10	0.17	58.1

D.2 Tourist Road- Current Year (2015), 20 % Bunching, Stage 1

MOVEMENT SUMMARY

Site: Stop 3-way Stage 1 (Minor Road) L

Staged crossing Stage 1 (Minor Road) at three-way intersection with 5-lane major road. Major road turn lane is treated as a full-length lane.
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Tourist Road											
1	L2	366	0.6	0.198	5.6	LOS A	0.0	0.0	0.00	0.53	54.9
2	T1	143	0.0	0.481	24.9	LOS C	2.3	16.1	0.85	1.11	28.0
Approach		509	0.4	0.481	11.1	LOS B	2.3	16.1	0.24	0.69	47.4
East: Cohoe Street											
4	L2	111	0.0	0.242	5.5	LOS A	0.0	0.0	0.00	0.15	57.0
5	T1	779	10.0	0.242	0.0	LOS A	0.0	0.0	0.00	0.06	59.3
Approach		889	8.8	0.242	0.7	NA	0.0	0.0	0.00	0.07	59.0
West: Warrego Highway											
12	R2	265	1.6	0.456	13.6	LOS B	2.6	18.6	0.73	0.99	47.9
Approach		265	1.6	0.456	13.6	NA	2.6	18.6	0.73	0.99	47.9
All Vehicles		1664	5.1	0.481	5.9	NA	2.6	18.6	0.19	0.41	53.3

D.3 Tourist Road- 10 Year Design Period, 20% Bunching

MOVEMENT SUMMARY

Site: Stop 3-way Stage 1 (Minor Road) L

Staged crossing Stage 1 (Minor Road) at three-way intersection with 5-lane major road. Major road turn lane is treated as a full-length lane.
Stop (Two-Way)
Design Life Analysis (Final Year): Results for 10 years

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Tourist Road											
1	L2	447	0.6	0.241	5.6	LOS A	0.0	0.0	0.00	0.53	54.9
2	T1	175	0.0	0.858	60.2	LOS F	6.1	43.0	0.97	1.43	18.4
Approach		621	0.4	0.858	21.0	LOS C	6.1	43.0	0.27	0.78	41.4
East: Cohoe Street											
4	L2	135	0.0	0.296	5.5	LOS A	0.0	0.0	0.00	0.15	57.0
5	T1	950	10.0	0.296	0.0	LOS A	0.0	0.0	0.00	0.06	59.3
Approach		1084	8.8	0.296	0.7	NA	0.0	0.0	0.00	0.07	59.0
West: Warrego Highway											
12	R2	323	1.6	0.718	22.5	LOS C	5.4	38.0	0.89	1.25	42.9
Approach		323	1.6	0.718	22.5	NA	5.4	38.0	0.89	1.25	42.9
All Vehicles		2029	5.1	0.858	10.4	NA	6.1	43.0	0.22	0.48	49.9

MOVEMENT SUMMARY

Site: Stop 3-way Stage 2 (Median) L

Staged crossing Stage 2 (Median) at three-way intersection with 5-lane major road.
Give-way behaviour assumed at Stage 2.
Giveway / Yield (Two-Way)
Design Life Analysis (Final Year): Results for 10 years

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Median Storage Area											
2	T1	135	0.0	0.292	6.3	LOS A	1.2	7.8	0.66	0.83	47.3
3	R2	40	0.0	0.292	7.6	LOS A	1.2	7.8	0.66	0.83	46.7
Approach		175	0.0	0.292	6.6	LOS A	1.2	7.8	0.66	0.83	47.2
West: Warrego Highway											
10	L2	76	1.7	0.240	5.5	LOS A	0.0	0.0	0.00	0.11	57.1
11	T1	743	18.5	0.240	0.0	LOS A	0.0	0.0	0.00	0.05	59.4
Approach		819	16.9	0.240	0.5	NA	0.0	0.0	0.00	0.06	59.2
All Vehicles		993	14.0	0.292	1.6	NA	1.2	7.8	0.12	0.19	57.8

D.4 Tourist Road- 20 Year Design Period, 20% Bunching

MOVEMENT SUMMARY

Site: Stop 3-way Stage 1 (Minor Road) L

Staged crossing Stage 1 (Minor Road) at three-way intersection with 5-lane major road. Major road turn lane is treated as a full-length lane.
Stop (Two-Way)
Design Life Analysis (Final Year): Results for 20 years

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Tourist Road											
1	L2	544	0.6	0.294	5.6	LOS A	0.0	0.0	0.00	0.53	54.9
2	T1	213	0.0	1.746	734.9	LOS F	63.6	445.2	1.00	3.87	2.4
Approach		757	0.4	1.746	210.6	LOS F	63.6	445.2	0.28	1.47	12.0
East: Cohoe Street											
4	L2	164	0.0	0.360	5.5	LOS A	0.0	0.0	0.00	0.15	56.9
5	T1	1157	10.0	0.360	0.0	LOS A	0.0	0.0	0.00	0.06	59.3
Approach		1322	8.8	0.360	0.7	NA	0.0	0.0	0.00	0.07	59.0
West: Warrego Highway											
12	R2	394	1.6	1.243	257.4	LOS F	57.3	406.7	1.00	4.27	11.4
Approach		394	1.6	1.243	257.4	NA	57.3	406.7	1.00	4.27	11.4
All Vehicles		2473	5.1	1.746	105.9	NA	63.6	445.2	0.25	1.17	21.2

MOVEMENT SUMMARY

Site: Stop 3-way Stage 2 (Median) L

Staged crossing Stage 2 (Median) at three-way intersection with 5-lane major road.
Give-way behaviour assumed at Stage 2.
Giveway / Yield (Two-Way)
Design Life Analysis (Final Year): Results for 20 years

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Median Storage Area											
2	T1	164	0.0	0.459	10.2	LOS B	2.1	13.7	0.79	0.98	43.0
3	R2	48	0.0	0.459	11.9	LOS B	2.1	13.7	0.79	0.98	42.4
Approach		213	0.0	0.459	10.6	LOS B	2.1	13.7	0.79	0.98	42.9
West: Warrego Highway											
10	L2	92	1.7	0.293	5.5	LOS A	0.0	0.0	0.00	0.11	57.1
11	T1	906	18.5	0.293	0.0	LOS A	0.0	0.0	0.00	0.05	59.4
Approach		998	16.9	0.293	0.6	NA	0.0	0.0	0.00	0.06	59.2
All Vehicles		1211	14.0	0.459	2.3	NA	2.1	13.7	0.14	0.22	57.0

D.5 Herries Street- Current Layout (2015)

MOVEMENT SUMMARY

Site: herries st- current

New Site
Giveway / Yield (Two-Way)

Movement Performance - Vehicles												
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Cohoe Street											
1	L2	12	0.0	0.196	5.5	LOS A	0.0	0.0	0.00	0.02	58.1
2	T1	711	11.0	0.196	0.0	LOS A	0.0	0.0	0.00	0.01	59.9
3	R2	15	0.0	0.020	8.6	LOS A	0.1	0.5	0.53	0.68	51.2
Approach		737	10.6	0.196	0.3	NA	0.1	0.5	0.01	0.02	59.6
East: Herries Street											
4	L2	7	0.0	0.717	94.9	LOS F	2.4	16.9	0.96	1.09	15.1
5	T1	9	0.0	0.717	165.6	LOS F	2.4	16.9	0.96	1.09	15.1
6	R2	12	0.0	0.717	247.5	LOS F	2.4	16.9	0.96	1.09	15.1
Approach		28	0.0	0.717	180.6	LOS F	2.4	16.9	0.96	1.09	15.1
North: Cohoe Street											
7	L2	2	0.0	0.164	5.5	LOS A	0.0	0.0	0.00	0.00	58.3
8	T1	571	19.6	0.164	0.0	LOS A	0.0	0.0	0.00	0.00	59.9
9	R2	99	7.5	0.170	10.7	LOS B	0.6	5.4	0.63	0.84	49.5
Approach		672	17.7	0.170	1.6	NA	0.6	5.4	0.09	0.13	58.1
West: Herries Street											
10	L2	185	1.7	0.204	7.5	LOS A	0.8	5.8	0.45	0.70	52.0
Approach		185	1.7	0.204	7.5	LOS A	0.8	5.8	0.45	0.70	52.0
All Vehicles		1622	12.3	0.717	4.8	NA	2.4	16.9	0.11	0.16	55.2

D.6 Herries Street- Signalised Layout, 0 Year Design Period

MOVEMENT SUMMARY

Site: SIGNALS - Conversion

New Site
Signals - Fixed Time Isolated   Cycle Time = 30 seconds (Practical Cycle Time)

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Cohoe Street											
1	L2	100	0.0	0.570	13.1	LOS B	3.9	36.1	0.75	0.69	50.9
2	T1	679	14.5	0.570	7.9	LOS A	4.9	48.3	0.81	0.70	52.7
Approach		779	12.6	0.570	8.6	LOS A	4.9	48.3	0.80	0.70	52.5
East: Herries Street											
4	L2	42	17.0	0.041	7.1	LOS A	0.1	1.4	0.43	0.64	51.6
Approach		42	17.0	0.041	7.1	LOS A	0.1	1.4	0.43	0.64	51.6
North: Cohoe Street											
7	L2	7	0.0	0.236	7.2	LOS A	0.9	9.9	0.49	0.36	56.1
8	T1	491	18.9	0.236	1.6	LOS A	0.9	9.9	0.49	0.35	57.7
9	R2	215	5.7	0.310	8.8	LOS A	1.4	11.3	0.66	0.73	51.0
Approach		713	14.7	0.310	3.9	LOS A	1.4	11.3	0.54	0.47	55.5
West: Herries Street											
10	L2	245	4.2	0.328	17.6	LOS B	1.7	13.1	0.90	0.76	45.4
Approach		245	4.2	0.328	17.6	LOS B	1.7	13.1	0.90	0.76	45.4
All Vehicles		1779	12.4	0.570	7.9	LOS A	4.9	48.3	0.70	0.61	52.5

D.7 Herries Street- Signalised layout, 10 Year Design Period

MOVEMENT SUMMARY

Site: SIGNALS - Conversion

New Site
Signals - Fixed Time Isolated   Cycle Time = 30 seconds (Practical Cycle Time)
Design Life Analysis (Final Year): Results for 10 years

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Cohoe Street											
1	L2	122	0.0	0.699	14.8	LOS B	5.7	51.9	0.81	0.79	49.9
2	T1	828	14.5	0.699	9.7	LOS A	7.0	68.8	0.87	0.84	51.3
Approach		950	12.6	0.699	10.4	LOS B	7.0	68.8	0.86	0.83	51.1
East: Herries Street											
4	L2	51	17.0	0.050	7.2	LOS A	0.2	1.7	0.43	0.65	51.6
Approach		51	17.0	0.050	7.2	LOS A	0.2	1.7	0.43	0.65	51.6
North: Cohoe Street											
7	L2	9	0.0	0.288	7.2	LOS A	1.2	12.5	0.51	0.37	56.1
8	T1	598	18.9	0.288	1.7	LOS A	1.2	12.5	0.51	0.36	57.6
9	R2	262	5.7	0.400	10.0	LOS A	2.1	16.8	0.76	0.76	50.2
Approach		869	14.7	0.400	4.2	LOS A	2.1	16.8	0.59	0.48	55.2
West: Herries Street											
10	L2	299	4.2	0.400	17.9	LOS B	2.1	16.2	0.91	0.77	45.3
Approach		299	4.2	0.400	17.9	LOS B	2.1	16.2	0.91	0.77	45.3
All Vehicles		2169	12.4	0.699	8.9	LOS A	7.0	68.8	0.75	0.68	51.7

D.8 Herries Street- Signalised Layout, 20 Year Design Period

MOVEMENT SUMMARY

Site: SIGNALS - Conversion

New Site
Signals - Fixed Time Isolated   Cycle Time = 30 seconds (Practical Cycle Time)
Design Life Analysis (Final Year): Results for 20 years

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Cohoe Street											
1	L2	149	0.0	0.769	14.7	LOS B	7.8	73.9	0.79	0.78	48.8
2	T1	1009	14.5	0.769	11.7	LOS B	8.6	84.3	0.92	0.94	50.1
Approach		1157	12.6	0.769	12.1	LOS B	8.6	84.3	0.90	0.92	50.0
East: Herries Street											
4	L2	63	17.0	0.061	7.2	LOS A	0.2	2.1	0.43	0.65	51.6
Approach		63	17.0	0.061	7.2	LOS A	0.2	2.1	0.43	0.65	51.6
North: Cohoe Street											
7	L2	11	0.0	0.351	7.3	LOS A	1.5	16.1	0.54	0.39	55.9
8	T1	729	18.9	0.351	1.8	LOS A	1.5	16.1	0.54	0.38	57.5
9	R2	319	5.7	0.526	11.7	LOS B	3.0	24.5	0.86	0.78	49.0
Approach		1059	14.7	0.526	4.8	LOS A	3.0	24.5	0.63	0.50	54.6
West: Herries Street											
10	L2	364	4.2	0.488	18.1	LOS B	2.6	20.2	0.93	0.78	45.2
Approach		364	4.2	0.488	18.1	LOS B	2.6	20.2	0.93	0.78	45.2
All Vehicles		2643	12.4	0.769	9.9	LOS A	8.6	84.3	0.79	0.73	51.0

D.9 James Street- Current Year (2015)

MOVEMENT SUMMARY

Site: Stop 3-way Stage 1 (Minor Road) L

Staged crossing Stage 1 (Minor Road) at three-way intersection with 5-lane major road. Major road turn lane is treated as a full-length lane.
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: James Street (Stage 1)											
1	L2	177	3.0	0.165	9.5	LOS A	0.7	5.3	0.40	0.89	51.3
2	T1	153	0.7	0.503	24.8	LOS C	2.4	17.3	0.85	1.12	27.9
Approach		329	1.9	0.503	16.6	LOS C	2.4	17.3	0.61	0.99	40.8
East: Cohoe Street											
4	L2	68	0.0	0.182	5.5	LOS A	0.0	0.0	0.00	0.13	57.0
5	T1	559	21.3	0.182	0.0	LOS A	0.0	0.0	0.00	0.06	59.3
Approach		627	19.0	0.182	0.6	NA	0.0	0.0	0.00	0.06	59.1
West: Cohoe Street											
12	R2	346	0.9	0.509	12.4	LOS B	3.2	23.0	0.70	1.00	48.7
Approach		346	0.9	0.509	12.4	NA	3.2	23.0	0.70	1.00	48.7
All Vehicles		1303	9.9	0.509	7.8	NA	3.2	23.0	0.34	0.55	51.2

MOVEMENT SUMMARY

Site: Stop 3-way Stage 2 (Median) L

Staged crossing Stage 2 (Median) at three-way intersection with 5-lane major road.
Give-way behaviour assumed at Stage 2.
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Median Storage Area											
3	R2	153	0.7	0.211	3.4	LOS A	0.7	4.0	0.56	0.56	48.2
Approach		153	0.7	0.211	3.4	LOS A	0.7	4.0	0.56	0.56	48.2
West: Cohoe Street											
11	T1	724	15.8	0.205	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		724	15.8	0.205	0.0	NA	0.0	0.0	0.00	0.00	60.0
All Vehicles		877	13.2	0.211	0.6	NA	0.7	4.0	0.10	0.10	58.6

D.10 James Street- 10 Year Design Period

MOVEMENT SUMMARY

Site: Stop 3-way Stage 1 (Minor Road) L

Staged crossing Stage 1 (Minor Road) at three-way intersection with 5-lane major road. Major road turn lane is treated as a full-length lane.
Stop (Two-Way)
Design Life Analysis (Final Year): Results for 10 years

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: James Street (Stage 1)											
1	L2	216	3.0	0.215	9.9	LOS A	0.9	7.0	0.45	0.91	51.0
2	T1	186	0.7	0.882	62.0	LOS F	6.8	48.4	0.97	1.49	18.0
Approach		402	1.9	0.882	34.0	LOS D	6.8	48.4	0.69	1.18	32.7
East: Cohoe Street											
4	L2	83	0.0	0.221	5.5	LOS A	0.0	0.0	0.00	0.13	57.0
5	T1	681	21.3	0.221	0.0	LOS A	0.0	0.0	0.00	0.06	59.3
Approach		765	19.0	0.221	0.6	NA	0.0	0.0	0.00	0.06	59.1
West: Cohoe Street											
12	R2	422	0.9	0.758	19.8	LOS C	6.6	47.5	0.87	1.31	44.3
Approach		422	0.9	0.758	19.8	NA	6.6	47.5	0.87	1.31	44.3
All Vehicles		1589	9.9	0.882	14.1	NA	6.8	48.4	0.41	0.68	46.8

MOVEMENT SUMMARY

Site: Stop 3-way Stage 2 (Median) L

Staged crossing Stage 2 (Median) at three-way intersection with 5-lane major road.
Give-way behaviour assumed at Stage 2.
Giveway / Yield (Two-Way)
Design Life Analysis (Final Year): Results for 10 years

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Median Storage Area											
3	R2	186	0.7	0.313	5.5	LOS A	1.2	6.7	0.67	0.76	45.8
Approach		186	0.7	0.313	5.5	LOS A	1.2	6.7	0.67	0.76	45.8
West: Cohoe Street											
11	T1	883	15.8	0.250	0.0	LOS A	0.0	0.0	0.00	0.00	59.9
Approach		883	15.8	0.250	0.0	NA	0.0	0.0	0.00	0.00	59.9
All Vehicles		1069	13.2	0.313	1.0	NA	1.2	6.7	0.12	0.13	58.2

D.11 James Street- 20 year design period

MOVEMENT SUMMARY

Site: Stop 3-way Stage 1 (Minor Road) L

Staged crossing Stage 1 (Minor Road) at three-way intersection with 5-lane major road. Major road turn lane is treated as a full-length lane.
Stop (Two-Way)
Design Life Analysis (Final Year): Results for 20 years

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: James Street (Stage 1)											
1	L2	263	3.0	0.287	10.6	LOS B	1.3	9.8	0.52	0.95	50.6
2	T1	227	0.7	1.744	729.1	LOS F	67.3	479.8	1.00	4.07	2.4
Approach		490	1.9	1.744	343.4	LOS F	67.3	479.8	0.74	2.39	7.1
East: Cohoe Street											
4	L2	102	0.0	0.270	5.5	LOS A	0.0	0.0	0.00	0.13	57.0
5	T1	831	21.3	0.270	0.0	LOS A	0.0	0.0	0.00	0.06	59.3
Approach		932	19.0	0.270	0.6	NA	0.0	0.0	0.00	0.06	59.1
West: Cohoe Street											
12	R2	515	0.9	1.210	219.5	LOS F	66.4	476.3	1.00	4.72	13.0
Approach		515	0.9	1.210	219.5	NA	66.4	476.3	1.00	4.72	13.0
All Vehicles		1936	9.9	1.744	145.5	NA	67.3	479.8	0.45	1.89	16.8

MOVEMENT SUMMARY

Site: Stop 3-way Stage 2 (Median) L

Staged crossing Stage 2 (Median) at three-way intersection with 5-lane major road.
Give-way behaviour assumed at Stage 2.
Giveway / Yield (Two-Way)
Design Life Analysis (Final Year): Results for 20 years

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Median Storage Area											
3	R2	227	0.7	0.496	9.6	LOS A	2.1	12.0	0.81	1.04	41.6
Approach		227	0.7	0.496	9.6	LOS A	2.1	12.0	0.81	1.04	41.6
West: Cohoe Street											
11	T1	1076	15.8	0.304	0.0	LOS A	0.0	0.0	0.00	0.00	59.9
Approach		1076	15.8	0.304	0.0	NA	0.0	0.0	0.00	0.00	59.9
All Vehicles		1303	13.2	0.496	1.7	NA	2.1	12.0	0.14	0.18	57.5

D.8 James Street- Options Investigation (signalisation)

MOVEMENT SUMMARY

Site: Site1 - Copy - Conversion

New Site
Signals - Actuated Isolated Cycle Time = 88 seconds (Practical Cycle Time)
Design Life Analysis (Final Year): Results for 10 years

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Cohoe Street											
2	T1	1180	15.1	0.590	13.8	LOS B	16.4	161.8	0.69	0.62	48.9
3	R2	564	1.1	2.634	1534.3	LOS F	172.9	1248.0	1.00	3.59	2.3
Approach		1744	10.6	2.634	505.7	LOS F	172.9	1248.0	0.79	1.58	6.5
East: James Street											
4	L2	288	1.3	0.525	33.9	LOS C	10.4	75.8	0.86	0.80	35.6
6	R2	249	1.0	0.459	33.2	LOS C	8.8	63.3	0.84	0.79	35.9
Approach		537	1.2	0.525	33.6	LOS C	10.4	75.8	0.85	0.80	35.7
North: Cohoe Street											
7	L2	111	0.0	0.517	18.5	LOS B	13.5	138.7	0.64	0.62	40.6
8	T1	910	22.1	0.517	13.0	LOS B	13.5	138.7	0.64	0.59	49.1
Approach		1022	19.7	0.517	13.6	LOS B	13.5	148.4	0.64	0.60	48.0
All Vehicles		3302	11.9	2.634	276.7	LOS F	172.9	1248.0	0.75	1.15	10.8

(Left and right out of James Street)

MOVEMENT SUMMARY

Site: Stop 3-way Stage 1 (Minor Road) L - Conversion

Staged crossing Stage 1 (Minor Road) at three-way intersection with 5-lane major road. Major road turn lane is treated as a full-length lane.
Signals - Fixed Time Isolated Cycle Time = 30 seconds (Practical Cycle Time)

Movement Performance - Vehicles

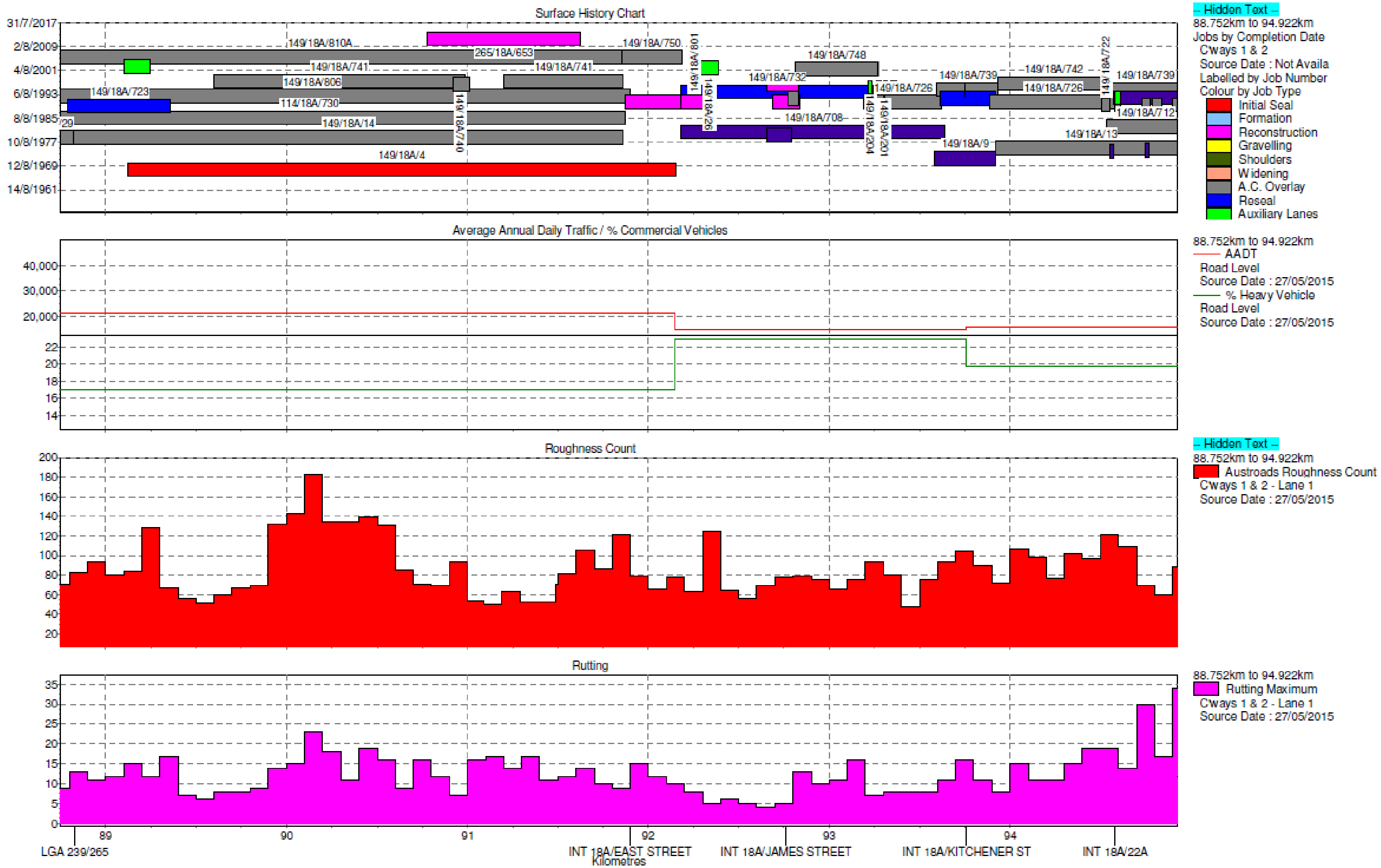
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: James Street (Stage 1)											
1	L2	177	3.0	0.162	14.4	LOS B	1.0	7.6	0.77	0.73	47.4
Approach		177	3.0	0.162	14.4	LOS B	1.0	7.6	0.77	0.73	47.4
East: Cohoe Street											
4	L2	68	0.0	0.605	16.3	LOS B	4.4	44.5	0.90	0.80	48.8
5	T1	559	21.3	0.605	10.8	LOS B	4.4	44.5	0.90	0.80	50.5
Approach		627	19.0	0.605	11.4	LOS B	4.4	47.6	0.90	0.80	50.3
West: Cohoe Street											
12	R2	346	0.9	0.626	16.5	LOS B	4.8	34.8	0.91	0.85	46.2
Approach		346	0.9	0.626	16.5	LOS B	4.8	34.8	0.91	0.85	46.2
All Vehicles		1151	11.1	0.626	13.4	LOS B	4.8	47.6	0.89	0.80	48.5

(left out only from James Street)

Appendix E- Chartview Data

Queensland Government

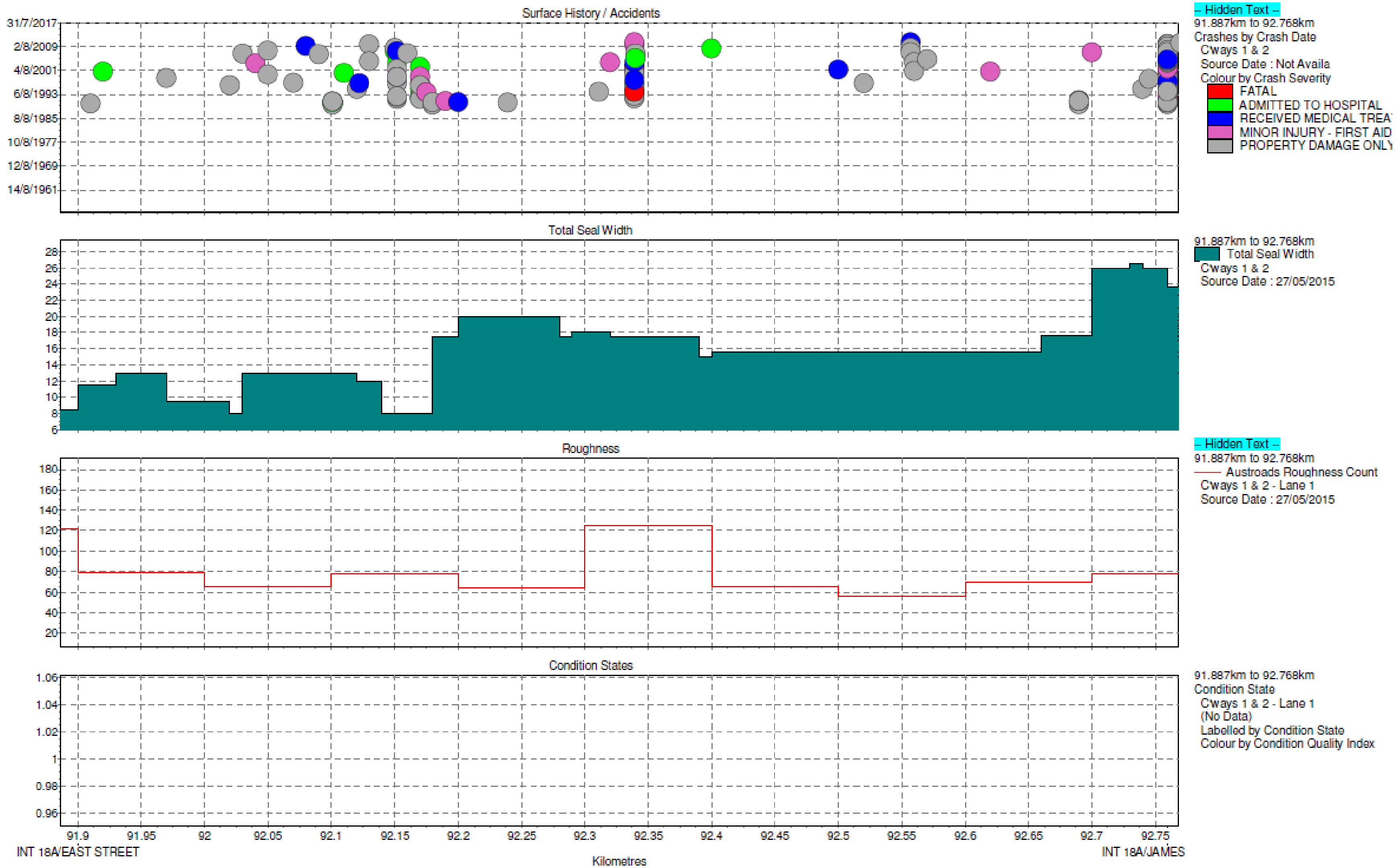
Road Section 18A - WARREGO HIGHWAY (IPSWICH - TOOWOOMBA) (95.0 km) from Roadlink refreshed on 27 May 2015 22:29



Scale : 350590 09:30 AM 09:30 AM Page 1 of 1 created with Armis ChartView

Queensland Government

Road Section 18A - WARREGO HIGHWAY (IPSWICH - TOOWOOMBA) (95.0 km) from Roadlink refreshed on 27 May 2015 22:29



Scale : 350590 09:43 AM 09:43 AM Page 1 of 1 created with Armis ChartView

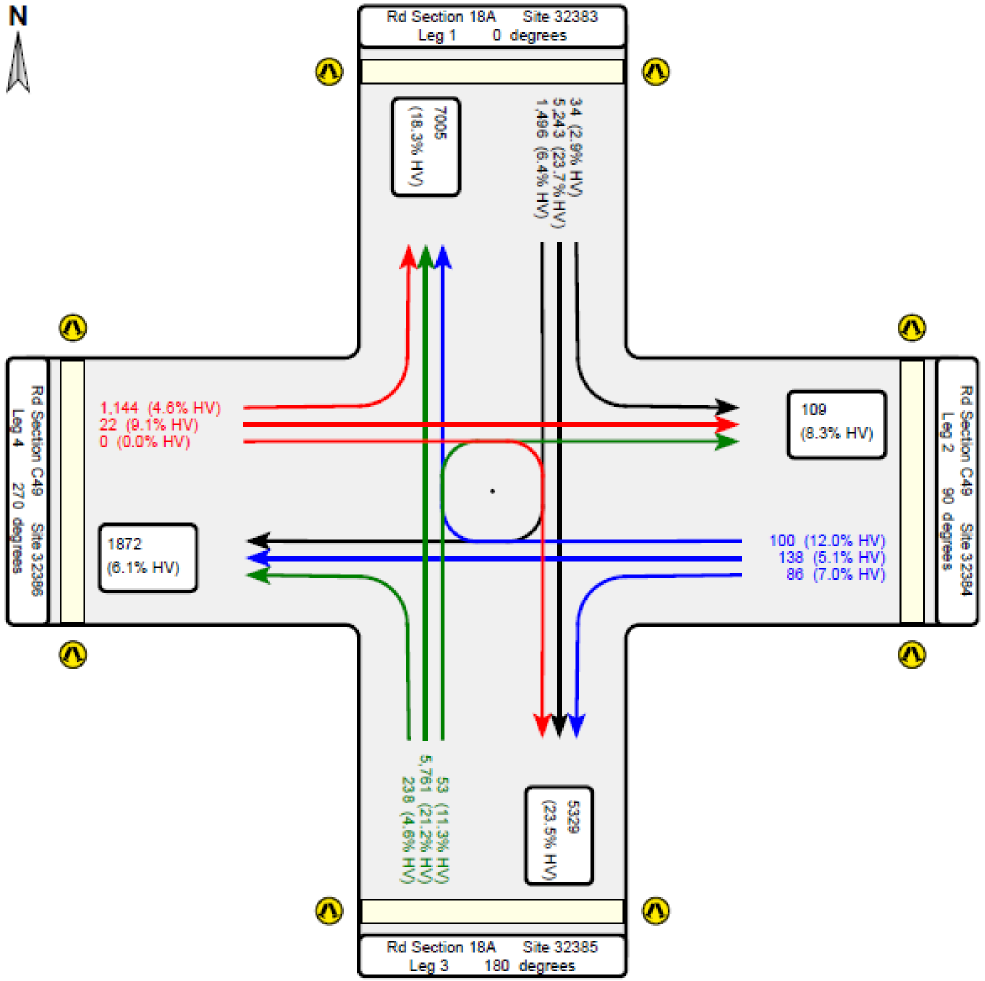
Appendix F- Herries Street DTMR Intersection Report

Traffic Analysis and Reporting System

Intersection Analysis Report

Region 202 - Darling Downs
Road Section 18A - Warrego Highway (Ipswich - Toowoomba)
Intersection 458 - 18A & Herries St
Thursday 26-May-2011 06:00 - 18:15

Summary



Leg	Angle	Road Section	Site	TDist	Site Description
1	0	18A	32383	92.690	Range side @ Herries St
2	90	C49	32384	0.001	Herries St to Range @ 18A 92.69Km
3	180	18A	32385	92.690	James St side @ Herries St
4	270	C49	32386	0.001	Herries St Town side @ 18A 92.69Km

Leg	Period	Left Turn	Through	Right Turn	U Turn	Pedestrians
1	Total	34 2.9% HV	5243 23.7% HV	1496 6.4% HV		
	AM Peak	4 0.0% HV	600 18.3% HV	273 6.6% HV		
	PM Peak	7 0.0% HV	484 22.3% HV	140 10.0% HV		
2	Total	86 7.0% HV	138 5.1% HV	100 12.0% HV		
	AM Peak	19 0.0% HV	15 0.0% HV	13 15.4% HV		
	PM Peak	6 16.7% HV	8 0.0% HV	11 27.3% HV		
3	Total	238 4.6% HV	5761 21.2% HV	53 11.3% HV		
	AM Peak	32 12.5% HV	513 20.9% HV	6 33.3% HV		
	PM Peak	29 0.0% HV	669 13.6% HV	4 0.0% HV		
4	Total	1144 4.6% HV	22 9.1% HV	0 NaN% HV		
	AM Peak	65 13.8% HV	0 0% HV	0 0% HV		
	PM Peak	190 3.2% HV	1 0.0% HV	0 0% HV		