6.6.4. Reinforced Concrete Section

6.6.4.1. Dimensions

As identified in section 6.6.3.2, there is a substantial stress concentration located in and around the location of the drainage pipe as well as high bending moments for asymmetrical conditions and high axial forces for both asymmetrical and symmetrical conditions. With the structural integrity of the arch culvert as a high priority, Hydro-Future has implemented a reinforced concrete section which will be designed as beams and columns in and around the drainage pipe void, the dimensions of this section can be seen below in Figure 142 to Figure 145. The dimensions of the structure which has been based on a visual observation of the stress concentrations in and around the drainage pipe was given a limiting value that it cannot be wider than the thickness of the culvert to prevent a large areas being removed which may cause further short and long term damage. Figure 145 shows the simplified RC section which Hydro-Future will be using throughout the calculations, this design is assumed to be conservative due to the removal of concrete to allow for 90 degree joints between the beams and columns. The reinforced concrete section has been implemented to ensure:

- Adequate sealing of the structure to prevent groundwater and soil erosion into the culvert.
- Cope with the stress concentrations identified in the finite element analysis.
- Increase the longevity of the arch with modernised materials which are likely to have a higher life span given the current age of the structure.
- Ensure sandstone bricks and mortar aren't left unrestrained due to their connection with the reinforced concrete.

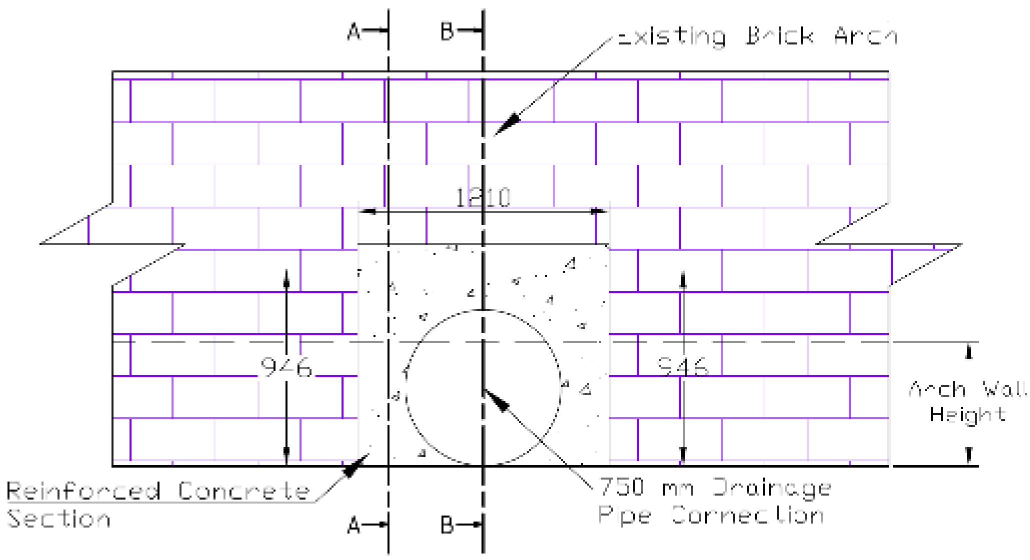

Figure 142: RC Section

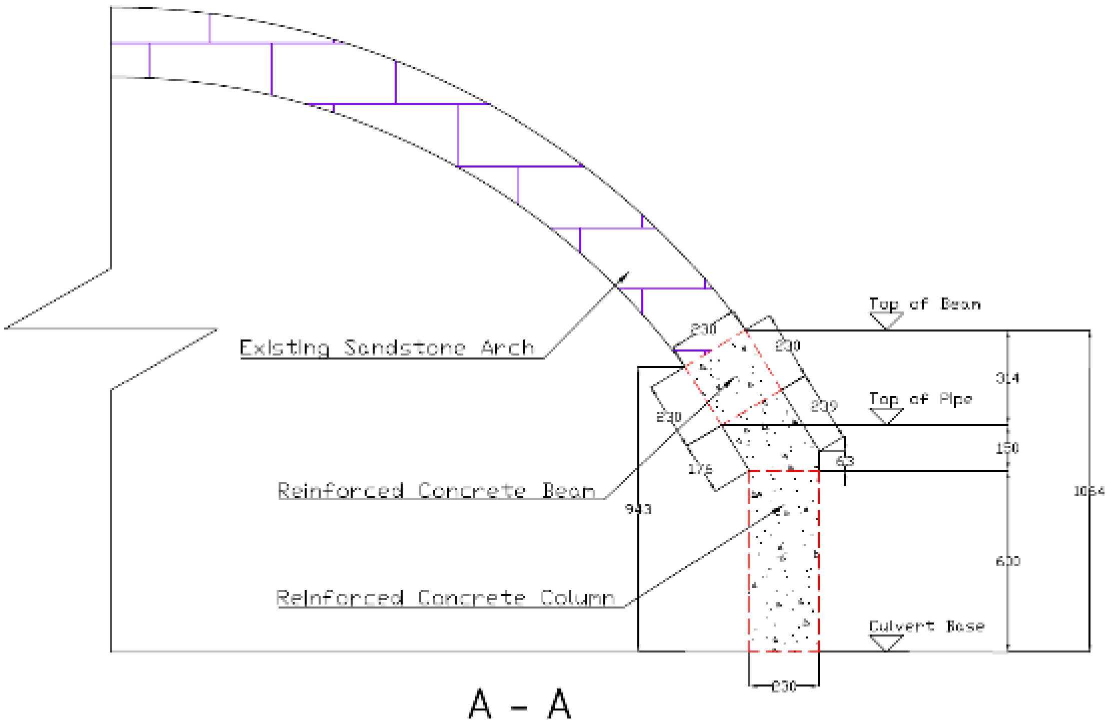

Figure 143: RC Section View (A - A)

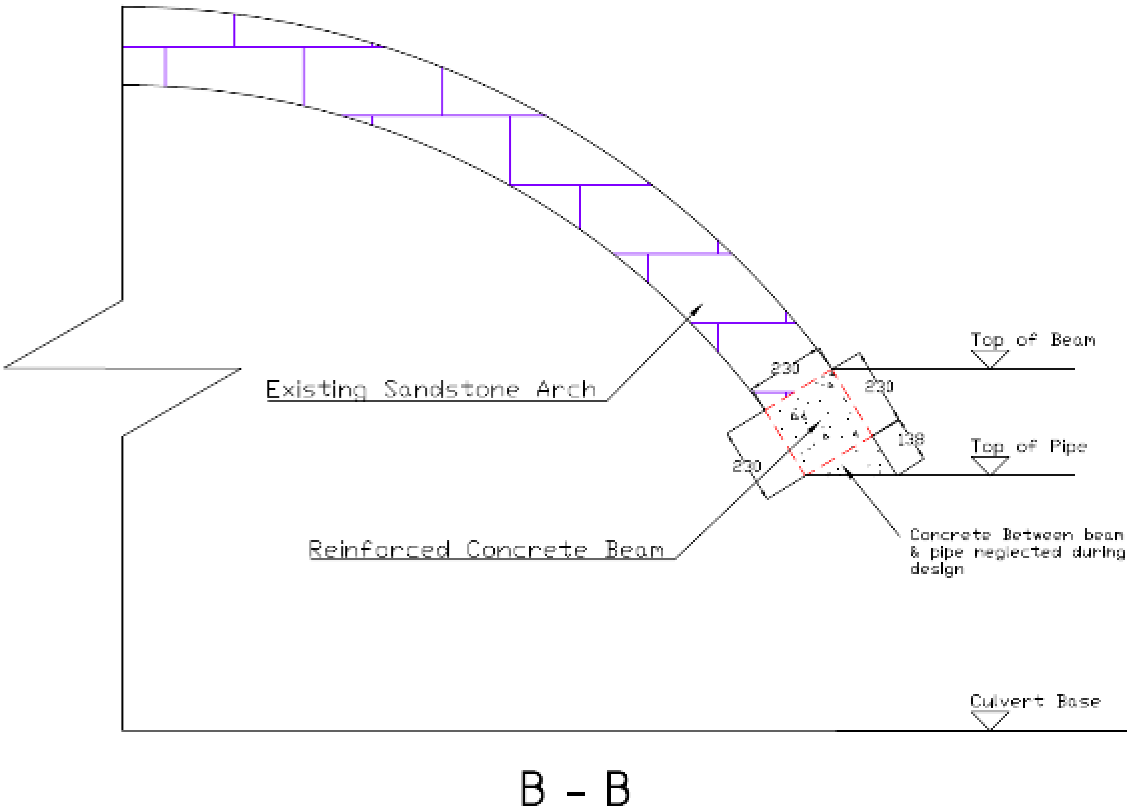

Figure 144: RC Section View (B - B)

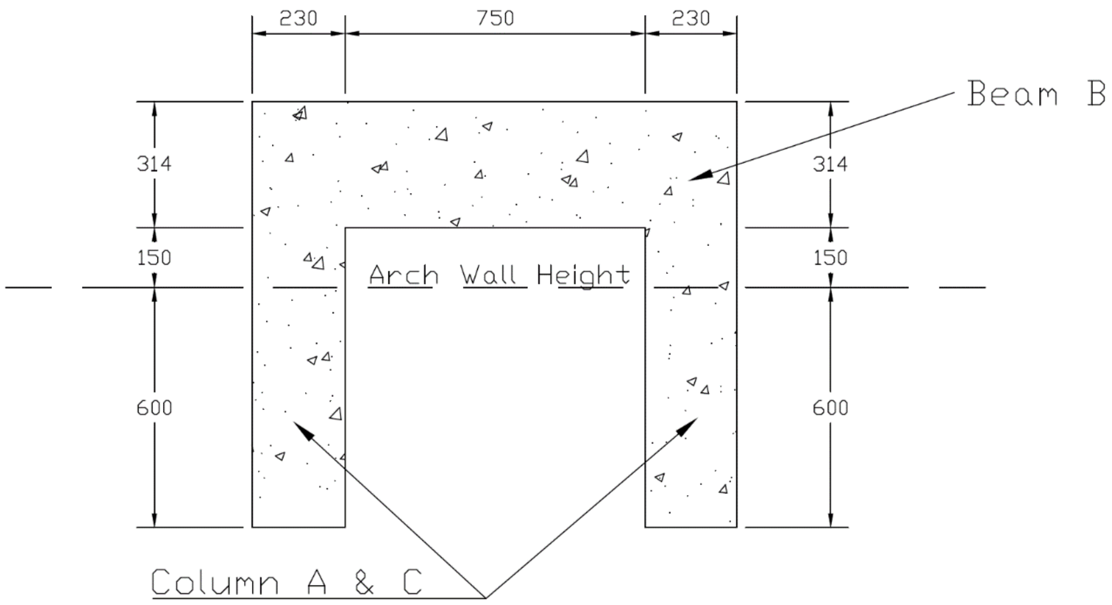

Figure 145: RC Section – Simplified

6.6.4.2. Dowel Bars

To ensure the connection between the reinforced concrete section and the sandstone arch is sufficient to resist shear and axial loads, steel dowel bars will be used to ensure compatibility between the concrete and the sandstone. As shown in Figure 146, there will be a difference in axial forces between the axial force acting on the column (N_{RC}) and the axial force acting on the sandstone arch(N_s). The change in axial force has occurred as the load transferred from Beam B will be less than the axial load in the sandstone arch due to the difference in load widths.

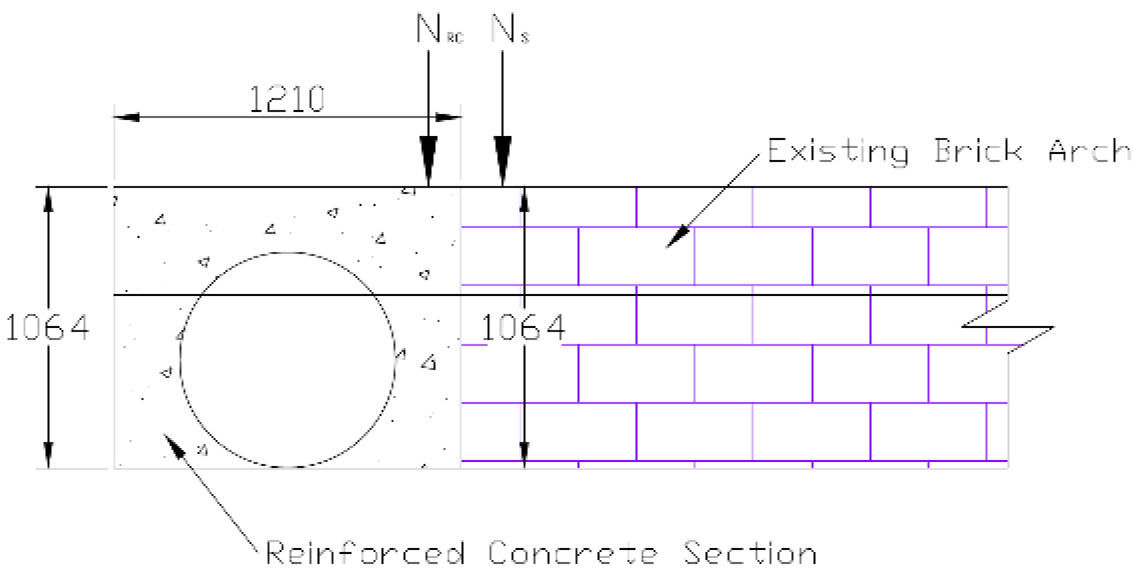

Figure 146: Axial Force Compatibility

The dowel bars will connect into a hole in the sandstone arch which compromises of a $30\ mm$ diameter at a depth of $50\ mm$ with an additional $50mm$ hole at a diameter of $12mm$ to ensure the dowel bar is kept central within the $100mm$ deep hole. The dowel bars will be adhesively connected to the sandstone using epoxy grout designed in accordance with section 17.1.8 of AS 3600.

6.6.4.3. Reinforced Concrete Design

The final design of the columns and beams are summarised in Table 57, with Figure 147, Figure 148, Figure 149 and Figure 150, showing where the reinforcement is to be placed. Detailed calculations are presented in Appendix 3.5 which include designs for combined actions, ultimate flexure, ultimate shear and reinforcement detailing requirements to ensure strength, serviceability and constructability requirements are adhered to.

Table 57: Summary of Reinforced Concrete Parameters.

Property	Columns	Beam
Dimensions (BxWxL)	230x230x1006	230x230x1210
$f'_c(MPa)$	40	40
Concrete Slump	110 mm	110 mm
Maximum Concrete Course Aggregate Size	20 mm	20 mm
Reinforcing Bars	4N16	4N16
Minimum Reinforcement Cover	30 mm	30 mm
Bar Overlap	300 mm	450 mm
Longitudinal Bar Bend	150^o	N/A
Ligature Bend	N/A	60^o
Bar Embedment	100 mm	100 mm
Bar Grout Length	50 mm	50 mm
Ligatures	7N12 @ 165cts	8N12 @ 165 cts
Dowel Bars	5N12 @ 175cts	6N12 @ 175cts
Dowel Bars Embedment	100 mm	100 mm
Dowel Bars Grout Length	50 mm	50 mm

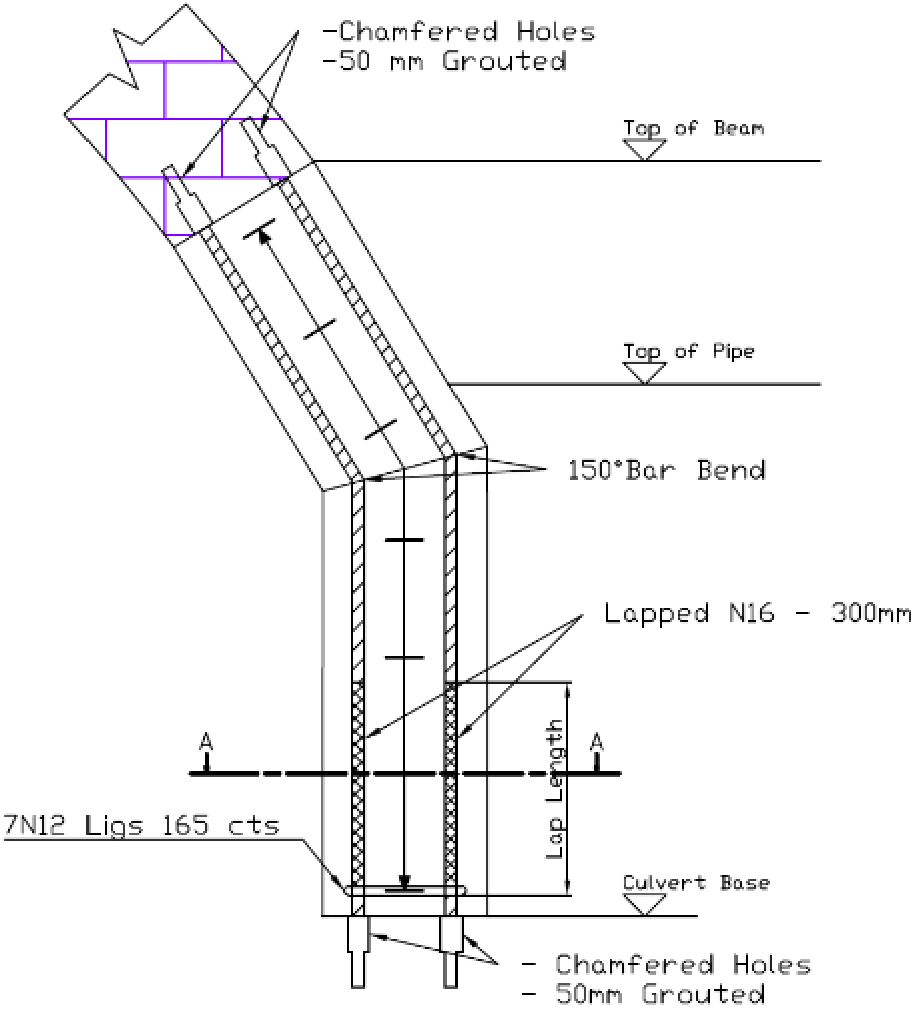

Figure 147: Column Detailing

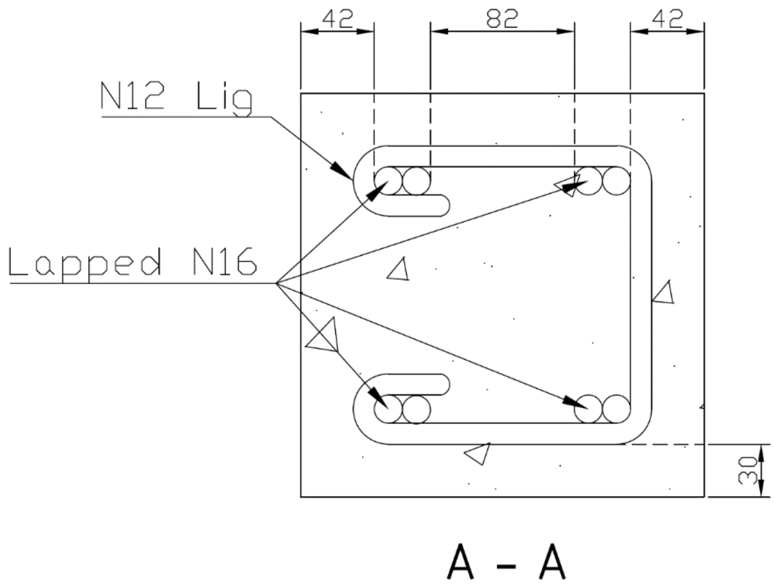

Figure 148: Column Detailing - Section View

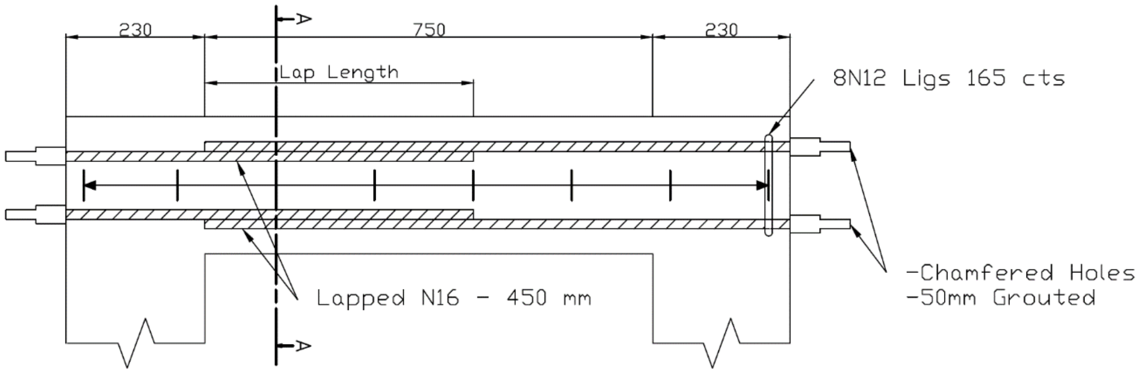

Figure 149: Beam Detailing

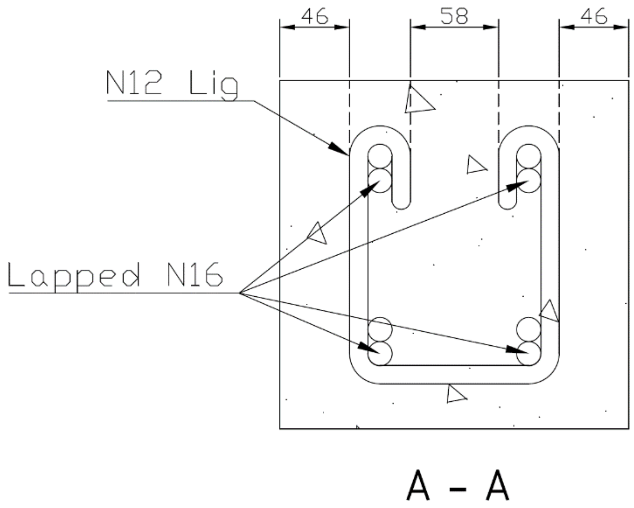

Figure 150: Beam Detailing - Section View

6.6.5. Structural Support System

6.6.5.1. Introduction

A temporary construction frame provides the support necessary to keep the culvert structure from collapsing during construction. After all associated construction has been completed, the temporary support system is removed. The dimensions of the support frame system is calculated and designed in the sections shown below.

6.6.5.2. Technical Specification

Frame Material

The material recommended in the design brief for the structural support system was steel or timber. Steel would cause corrosion problems if left uncoated or unchecked for a very long period of time, it's also heavier and harder to use as a construction material. Since the frame itself is a temporary structure it is assumed that a lighter weight material would be suitable for use in the design of the structural support system.

The material properties are derived from AS1720.1; Timber Structures, table H2.1, pgaa 155. The chosen material stress grade for the timber members is F34, which is the strongest F-Grade timber material available in the standard. The characteristics are listed in the specifications table shown below.

Table 58 Timber material characteristics (AS1720.1-2010 2010, pg 155; table H2.1)

Stress Grade	Bending (f'_b)	Tension parallel to grain (f'_t)		Shear in beam (f'_s)	Compression parallel to grain (f'_c)	Modulus of elasticity	Modulus of rigidity
		Hardwood	Softwood				
F34	84	51	42	6.1	63	21 500	1 430

Connection and Joint Properties

Common issues that arise in building timber connections is that the splitting of the members at connections occurs; splitting usually propagates perpendicular to the grain. Some examples of splitting are presented below. Splitting may occur if the member has insufficient edge distance (Frederick-University 2006, pg 1)

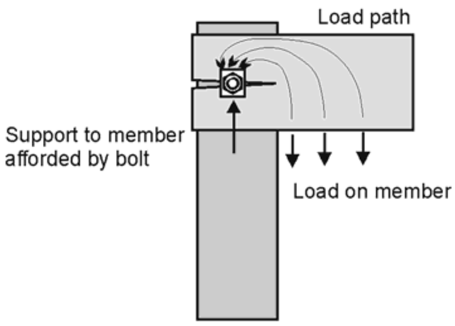

Figure 151 Example of timber joint splitting (p.2, Frederick-University 2006)

The Australian Standard; AS1720.1-2010, Cl4.4 details the characteristic capacities for bolted connections which generally includes bolt design which is utilised in the calculation procedures. Furthermore, AS1720 includes the required spacing, edge and end distance for bolts in Cl4.4.4, these connection distances shall ensure failures such as splitting won't occur during the design life of the structure.

6.6.6. Final Design Dimensions and Member Specifications

AutoCAD drawings showing plan view, side view, and front view and section views of the support system are shown below. Detailed calculations are presented in, with detailed construction drawings also available below. The table of members and connections is given in

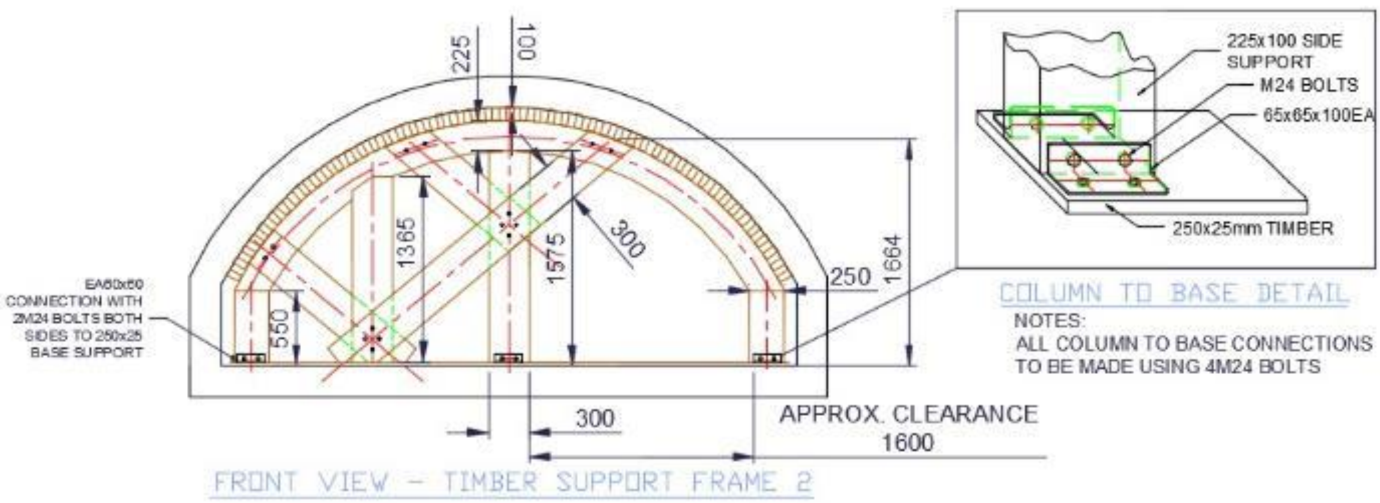

Figure 152 Front View of Support Structure, Frame 2

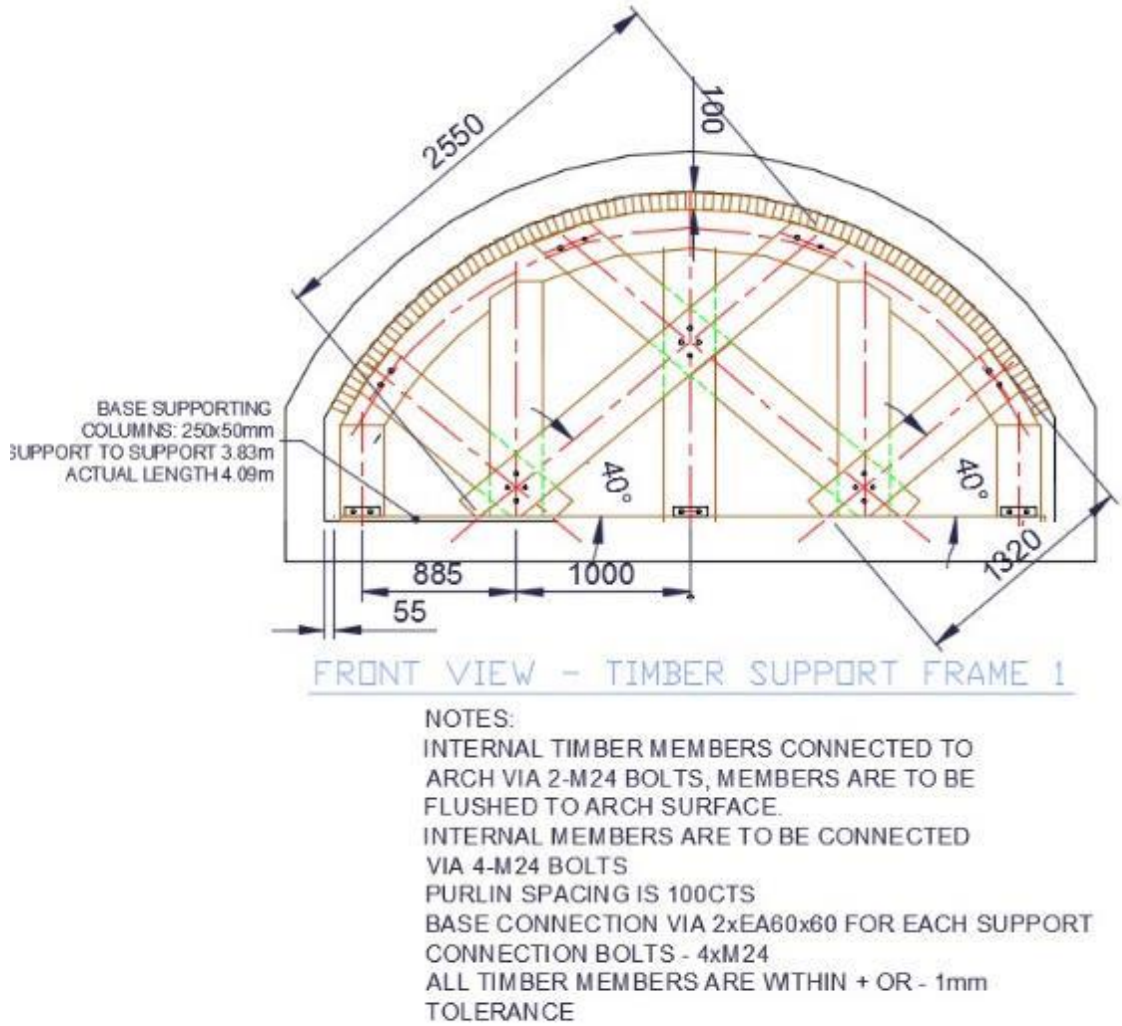

Figure 153 Front View of Support Structure, Frame 1

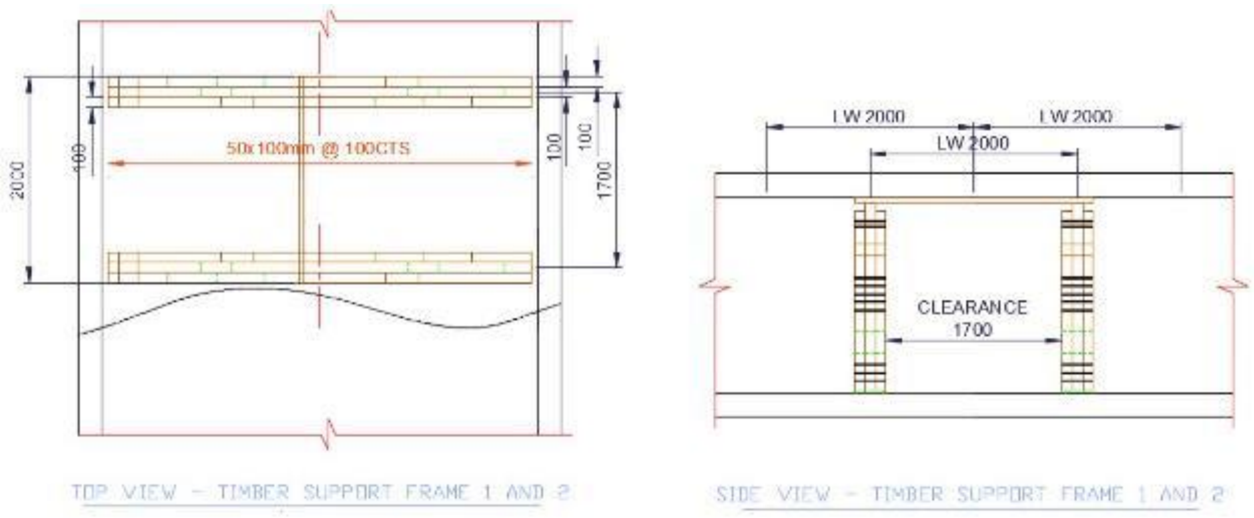

Figure 154 Top and Side View of Support Structure, Frame 1 & 2

Table 59 Timber support system table of all the members and connections

Table of Members Timber Support System							
Property:	Side Timber Support	Internal Support	Timber Arch Support	Purlins	Bolts	Connection Joint	Column to Base Support
Size	225x100mm	300x100mm	225x100mm	50x100	M24	65x65x5EA	225x50mm
Designation	F34	F34	F34	F34	Grade 8.8	Grade 300PLUS	F34
Quantity	4x0.55m	3x2.55m 1x1.13m 3x1.32m 2x1.575m (Cambered) 3x1.365m (Chamfered)	1x4.985m	55	36	12	1x4.09m

6.6.7. Construction Schedule

This section details an example of the construction schedule which includes the order of tasks to be completed during the construction timeline. The dates provided in the Gantt chart shown below do not reflect the actual dates which this project may be undertaken.

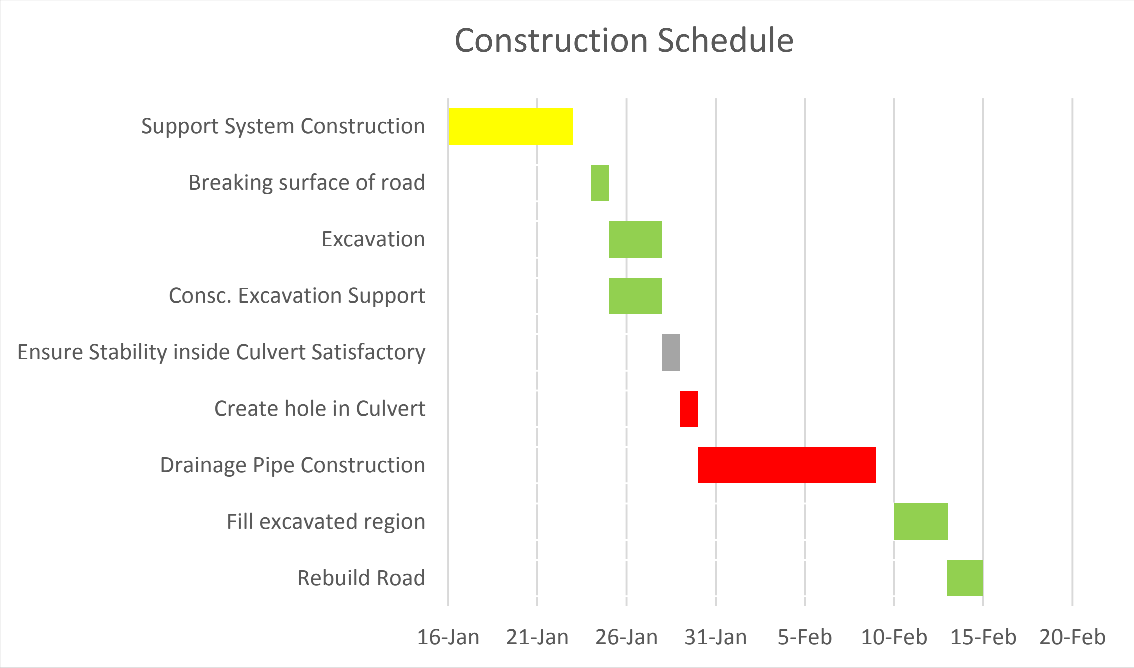

Figure 155 Construction Schedule

Table 60 Example construction schedule table

Task	Date of Construction	Days to complete
Support System Construction	16-Jan	7
Breaking surface of road	24-Jan	1
Excavation	25-Jan	3
Construct Excavation Support	25-Jan	3
Ensure Stability inside Culvert Satisfactory	28-Jan	1
Create hole in Culvert	29-Jan	1
Drainage Pipe Construction	30-Jan	10
Fill excavated region	10-Feb	3
Rebuild Road	13-Feb	2

As shown in

Table 60 , the construction has been split up into several tasks, a summary of these tasks and their construction extent is illustrated below.

- Support system construction:

1) The timber support system used to support the arch culvert during excavation and insertion of the drainage pipe into the arch culvert will require 14 days to construct. This project is fairly intensive, it will require at least 4 personnel to erect.
2) All timber members and equipment is carried inside the culvert and to the construction zone. Plastic must cover all equipment, furthermore it must be positioned above culvert surface level to ensure no damage occurs due to rising water level.
3) Battery powered LED lighting equipment is used to provide sufficient lighting inside the arch culvert structure during construction.
4) Suitable air quality in the culvert is required during the erection of the arch support system, this air quality is provided through an air quality monitoring device which will sound an alarm if the air present in the culvert is hazardous. Construction workers inside the culvert must carry respiratory equipment, such as respiratory masks to prevent any inhalation damage from occurring
5) Upon transport and setup of equipment and timber members, construction of the timber support frame is to commence. The flat wooden plate used to accommodate the supports is positioned inside the culvert, the arch timber member along with all internal members are bolted together inside the culvert and then tilted into place and bolted down into the flat wooden plate. Purlins are inserted above both of the erected frames and hammered into place if necessary, however the design should leave enough room for the purlins to be inserted into place.

- Breaking surface of road, Excavation, Ensure stability of Support System.

  The surface of the road must be removed via road excavation equipment. Upon removal of the top section of road, excavation of soil within the designated design zone of construction is to be completed using standard excavation machinery. An inspection of the timber support system inside the arch culvert must be completed periodically during excavation of soil, any defective members or failure must be reported and fixed immediately before any other construction work can commence.

- Drainage Pipe Connection

1) Once the excavation of the road and existing in-situ soils have been completely to expose the sandstone arch, the removal of sandstone bricks and mortar can occur from outside the culvert.
2) Once the required are of the sandstone has been removed the steel reinforcement can be placed which includes the dowel bars, longitudinal bars and shear ligatures, this task will occur from outside the culvert.
3) Formwork will be placed around the reinforcement to ensure the concrete is moulded correctly and has structural support during curing. The formwork will seal the inside of the culvert and the majority of the outside except for the top of the beam to ensure a gap allows concrete into the mould.
4) Pouring, compaction and vibration of the concrete can be undertaken once the formwork has been placed. The concrete will need to be cured for a minimum of 7 days to allow adequate strength before the excavated region can be filled. The formwork will permanently remain on the concrete after the excavation has been filled.
5) After 28 days where the concrete has gained it's the removal of the internal formwork and the temporary construction frame can take place.
6) After strength of concrete has been achieved, the timber support structure is carefully removed via the bolts and columns first, and then everything else after i.e., internal members, arch section, and purlins.

6.6.8. Safety

A task specific safety assessment form has been completed below. This form details the risks, and mitigation strategies during construction of the arch support system.

Task Specific Safety Assessment Form	
Department/Section:	**Structural and Geotechnical**
Task/ stage Name:	**Timber Structural Support System**
Brief Description of works to be undertaken	
• Management/Movement of timber inside arch culvert structure • Connection of timber members inside arch culvert system • Bolted connections • Cutting and remove section of sandstone arch to allow for the RC section and drainage pipe. • Installation of reinforcing steel, formwork and concrete along with placement of the stormwater drainage design pipe.	
Summary of major risks or hazards	
• Heavy lifting of timber, may cause strain/distress to personnel • Minor flooding risk during major rainfall event • Collapse hazard; fairly low, since construction commences before excavation and insertion of pipe into arch culvert structure. • Electrocution or damage to electrical equipment during rainfall event i.e. water level comes into contact with generator or external power source • Contaminants from construction work trapped within culvert may be hazardous, these contaminants may include dust , particulates, gases etc • High risk of injury due to the construction which will take place on the culvert within the excavated trench. • High risk of sandstone blocks falling during construction of the culvert.	
Mitigation strategies	
• Plastic cover all equipment and timber and ensure that it is all located above water level during a rainfall event • Use of rainfall warning system; local meteorology service can provide updates of weather conditions, other personnel located within the vicinity of the project can also provide warning of rainfall events. • Ensure all timber members are tightly secured in place to avoid being sweep or damaged during rainfall event	

• Use an air quality monitoring system to determine if the air inside the culvert is hazardous • Ensure all workings are wearing face masks or suitable respiratory protection such as breathing masks. • A worker should not remain inside the culvert during the excavation and demolistion of the arch culvert side wall.
Safety equipment required & number
• Standard construction equipment i.e. Hardhats, safety glasses, are to be worn and in addition larger rubber boots must be kept in close proximity in the event of water level presence. • Air quality sensor/monitoring device used to determine air quality inside culvert • Breathing masks must be used to avoid inhalation of harmful fumes trapped within the culvert

Task Specific Safety Assessment Form	
Department/Section:	**Structural and Geotechnical**
Task/ stage Name:	**Drainage Pipe Connection into Arch Culvert**

Brief Description of works to be undertaken

- Removal of sandstone blocks using a rock saw.
- Placement of reinforcement which includes drilling chamfer holes into the sandstone blocks.
- Placement of formwork around the reinforcement.
- Pouring of concrete.

Summary of major risks or hazards

- Cutting into the culvert may cause dust debris which can be hazardous for breathing.
- Flooding of the culvert or trench during a rainfall event may cause slip hazards and malfunctioning of trench machinery.
- Collapse of sandstone blocks may pose risks due to falling objects.

Mitigation strategies

- Ensure equipment and material is lowered into construction region carefully via rope or other equipment
- Collapse hazard mitigated via timber support system and temporary hydraulic jacks or lintels.
- Ensure the trench is not lines with unnecessary machinery and equipment and to remove all machinery and equipment upon completion of a task.
- Ensure all electrical equipment is covered during a rainfall event.
- Trench will be excavated wide enough to allow for adequate room for construction on the culvert.

Safety equipment required & number

- Hard Hats, eye protection, hearing protection, PPE, spotters, safety boots, high visibility clothing and long sleeve pants and shirts are to be worn.

6.7. Bill of Quantity

This section details the costing and quantity of material required for each component of the construction being undertaken. Rawlinsons Australian Construction Handbook (2015) was used for the majority of the costing, with other prices identified from online searches from manufacturer's websites.

Bill of Quantity						
Client: Tonkin Consulting						
Project: NORTH TERRACE DRAINAGE DESIGN						
Department: STRUTURAL AND GEOTECHNICAL						
#	**Item name**	**Reference and Item/Member Specification**	**Unit**	**Quantity**	**Rate**	**Cost ($)**
Subject: TIMBER STRUCTURE SUPPORT SYSTEM [5]						
1	Purlins 50x50mm	[2]*Greenmount Tim.&Building Supplies (Average price)* Carpentry, 2m long purlins,	0.9m[2]	55	[2]$6.95* ($/0.9m)	55x(2m) ($6.95/0.9m) =$849.0
2	Internal Members 300x100mm	[1]*Rawlinsons 2005; Edition 23 (Approx pricing)* [2]*Greenmount Tim.& Building Supplies (Average price)* [3]*Narangba Timbers (Over estimate)* 3x2.55m 1x1.13m 3x1.32m 2x1.575m (Cambered) 3x1.365m (Chamfered)	0.9m	19.985m	[1]$62.8 [2]$132.8* [3]$239.0	$2,948.9*
4	Flat Wooden Base	[2]*Greenmount Tim.&Building Supplies (Average price)* 1x4.09m	0.9m	4.09m	[2]$50.0*	$227.2*

[5] All timber members are F34 Ash Timeber

	250x25mm					
5	Side Timber Members 225x100mm	[2]*Greenmount Tim.&Building Supplies (Average price)* 4x0.55m	0.9m	0.55m	[2]$50.0*	$122.2
6	Arch Timber Member 225x100mm	[3]*Narangba Timbers; (Approx pricing)* 1x225x100mm, arching specially fabricated member as per design designation. Approx 5m	0.9m	5m	[2]$50.0*	$277.8*
7	M24 Bolts	[4]*exafast manufactured components; (Exact Price)* Bolts for column to base connection and general arch connections, 36 required in total	No.	36+5 Extra = 41	$2.77	$113.6
8	Labour Costs	The labour costing is based off the time taken for construction of the timber support system, which is 7 days. Labour costing is assumed to equal $25 per hour for 7 hours of work a day for 4 construction personnel, coming to a total of $4,900	No.	4 Personnel	$25 per hour	4 x 7 days x 7 hours per day x $25 per hour = $4,900
			Material Sub-total			**$4,538.70**
			Sub- Total (1)			**$9,438.70**

#	Item name	Reference and Item/Member Specification	Unit	Quantity	Rate	Cost ($)
Subject: Arch Culvert Connection						
9	Concrete (40 MPa)	Concrete (40 Mpa) mix (Rawlinson's, 2015)	m^3	0.48	[2]$243*($/0.48m)	121.50
10	Steel Reinforcement	N16 steel longitudinal reinforcement (Wire Industries, 2011)	m	17.2	$24.3 per 6 m	72.9
11	Steel Reinforcement	N12 Ligatures - L062020 Trench mesh Ligature 200 X 200 (Wire Industries, 2011)	No.	22	$103.8 per 100	103.8
12	Steel Reinforcement	Tie Wire (Wire Industries, 2011)	No.	48	$65.9 per BNDL	65.9
13	Steel Reinforcement	N12 Dowel Bars (Wire Industries, 2011)	m	4.8	$13.7 per 6 m	13.7
14	Construction	Cutting into the arch culvert to allow for the RC section and drainage pipe.	Hours	8	$25 per hour	200
15	Construction	Drilling of dowel and longitudinal reinforcement holes and the placement of steel.	Hours	72	$25 per hour	1800
16	Construction	Placement of Formwork around the RC section.	Hours	16	$25 per hour	400
17	Construction	Placement, compaction and vibration of concrete.	Hours	4	$25 per hour	100
			Material Sub-total			377.8
			Sub-total (2)			**2877.8**
#	**Item name**	**Catalogue reference or special specification (if needed)**	**Unit**	**Quantity**	**Rate**	**Cost ($)**
Subject: Trench Box						
18	Side Panel	Aluminium Alloy Al6061 – T6 5000x3000x50 (Alibaba.com 2015)	ea	2	16139.25	32,278.50

#	Item name	Catalogue reference or special specification (if needed)	Unit	Quantity	Rate	Cost ($)
19	Steel Brackets – Front	Fabricated from steel plate (Rawlinsons structural steel $1650 p/t)	ea	2	52.17	104.34
20	Steel Brackets – Rear	Fabricated from steel plate 210x210x9 (Rawlinsons structural steel $1650 p/t)	Ea	4	1.85	7.40
21	Front Strut -1000mm	Fabricated RHS 500x200x9 1000mm length(Rawlinsons structural steel $1650 p/t)	Ea	1	11.95	11.95
22	Front Strut – 1200 mm	Fabricated RHS 500 x 200 x 9 1200 mm length (Rawlinsons structural steel $1650 p/t)	Ea	1	14.35	14.35
23	Front Strut – 3300mm	Fabricated RHS 500x200x9 3300mm length(Rawlinsons structural steel $1650 p/t)	Ea	1	39.45	39.45
24	Rear strut – 1000 mm	SHS 200x200x9 1000mm length(Rawlinsons structural steel $1650 p/t)	Ea	2	5.54	11.08
25	Rear strut – 1200 mm	SHS 200x200x9 1200mm length(Rawlinsons structural steel $1650 p/t)	ea	2	5.74	11.47
26	Rear Strut – 3300 mm	SHS 200x200x9 3300mm length(Rawlinsons structural steel $1650 p/t)	Ea	2	15.78	31.55
27	Bolts	M30 8.8 grade	Ea	12	30.90	370.80
			Sub-total (1)			**32,880.89**
Subject: Gabion Retaining Wall						
28	Gabion Type A	2000x1000x400, double twist hexagonal mesh 80x100 (www.gabion1.com.au)	ea	54	73.86	3,988.44
29	Gabion Type B	1000x400x400, double twist hexagonal mesh 80x100 (www.gabion1.com.au)	ea	108	32.29	3,487.32

#	Item name	Catalogue reference or special specification (if needed)	Unit	Quantity	Rate	Cost ($)
30	Gabion Mattress Type 1	2000x2000x20 double twist hexagonal mesh 60x80 (www.gabion1.com.au)	ea	48	68.12	3,269.72
31	Gabion Mattress Type 2	5200x4500x20 double twist hexagonal mesh 60x80 (www.gabion1.com.au)	ea	3	102.44	307.32
32	Excavations	Excavate on a riverbed level for retaining wall (Rawlinsons 2015)	Cum	96	88.65	8,510.40
33	Stonefill	Sandstone (Rawlinsons 2015)	Cum	138.68	340	47,151.20
34	Geotextile	2 metre wide roll (alibaba.com 2015)	Metres	240	11.68	2,803.20
35	Labour	2 labourers	p/h	280	50	14,000
			Sub-total (3)			**83,517.60**
Subject: Trench Excavations						
36	Bulk Excavation	Excavation of trench material (Clay) and cartage (Rawlinsons 2015) inc labour	Cum	1149	84	96,516
37	Tip fees	Disposal of low level waste to landfill (Rawlinsons 2015) inc labour	Tonne	1838	80	147,040
38	Backfilling	Clean Sand and compaction(Rawlinsons 2015) in labour	Cum	657	62	40,734
39	Road Re-instatement	Rate for reinstatement of a single land including asphalt and base course(Rawlinsons 2015) inc labour	m	720	208	149,760
			Sub-total (4)			**434,050**
Subject: Rainwater tank slab						
40	Concrete (40 MPa)	Concrete (40 Mpa) mix (Rawlinson's, 2015)	m^3	0.4	$243	97.20
41	Steel (SL62)	SL62 Steel Mesh	ea	1	$22.02	22.02
			Sub-total per slab (5)			**119.22**
			Total			**562,884.21**

7. Transport and Traffic Engineering

A significant section of the final design involved transport and traffic engineering, which can be broken down into the following sections:

- Traffic Modelling for Detours – Completing traffic modelling to understand the best routes for traffic detours and the most appropriate times to implement these.
- Business and Residential Access – Understanding the needs of local businesses, the location of residential estates and how construction would impact these. This also included analysing how businesses and homes could be accessed during full closures.
- Pedestrian Access – The proximity to the CBD and the high number of businesses and residential estates within the construction zone means that there are a significant amount of pedestrians which use this area. It was important to understand how they could access locations within the construction zone whilst ensuring their safety is highlighted.
- Public Transport – Bus services frequently use this corridor. The public transport section involved analysing which services utilise this carriageway and what times these services operate. It also involved planning the relocation of bus stops.
- Traffic Management Plans – Traffic management plans were developed to display how traffic would be diverted, safely, during the construction stage.
- Safety and Training – Safety considerations for workers in the construction zone was analysed, as well as relevant training that is required for traffic and transport workers on site.
- Costing – Finally the implementation of traffic management plans were costed.

It was vital that these subjects were studied in detail, as this section of North Terrace is incredibly close to the CBD and, therefore, experiences high traffic volumes which consist of private and public vehicles and pedestrians. The aim in analysing each of these sections was to ensure the worksite remained safe and impacts to traffic were minimised.

7.1. Traffic Modelling

To determine the most appropriate detour routes, the transport and traffic team undertook SIDRA modelling of the intersections which are located within, and surround, the construction zone.

Base models which replicated the existing conditions were modelled, with the addition of increased traffic volumes and, where appropriate, infrastructure (eg. temporary traffic signals) to understand how the intersections capacity would change, if the intersection was used as a detour.

To ensure these accurately replicated the existing conditions, drawings and traffic volumes were provided by the DPTI. The use of these is discussed in Section 7.1.1

Three detours were considered for analysis, in both the inbound and outbound direction, and during the inter-peak and after-peak time intervals.

It should be noted that the term "inbound" was used to describe traffic travelling into the city and "outbound" describes traffic flow in the opposite direction.

The process which was undertaken to complete this analysis, as well as a discussion of the results and recommendations can be found below in Sections 7.1.1.1 to 7.1.1.5.

7.1.1. Data Input

The accuracy of a SIDRA intersection model is very much dependent on the input used by the software operator to create the model. Table 61, below, summarises the input required for each model, and where this information was retrieved from, to model the intersections considered. Each input item is discussed in more detail in Section 7.1.1.

Table 61 SIDRA Input Summary

Input Required	Details of Input	Source of Input
1. Intersection layout	Origin-destination movements from each arm of the intersection and any bus priority treatments.	DPTI Intersection Drawings (see point 2).
2. Intersection geometry	Number of approach and exit lanes, width of each lane, allowable movement from each lane, width of median and length of lane (if short lane).	DPTI Intersection Drawings (please see Appendix, Section 4.1 for copies of these) and Google Earth.
3. Pedestrian data (where applicable)	For intersections very close to the CBD the required crossing times for pedestrians was used as input.	DPTI SCATS Summaries (please see Appendix, Section 4.1 for copies of these).
4. Traffic volumes	Number of light vehicles, heavy vehicles and buses passing through the intersection per hour, in each direction.	DPTI Vehicle Turning Movement Survey (please see Appendix, Section 4.1, for copies of these)

5. Traffic signal phasing (where applicable)	For signalised intersections, the phases which run in each signal group and the amount of red, yellow and green time for these phases in the AM peak, PM peak, inter-peak and after-peak period.	DPTI SCATS Summaries

7.1.1.1. Intersection Layout

The intersection layout input is used to show the general shape of the intersection, as well as the allowed movements. Whilst inputting this information, the user can also specify, for each arm of the intersection, if the road is one or two way and allowable movements.

The allowable movements are referred to as origin-destination movements, and it is critical that these are defined correctly, to avoid incorrect volume input and output errors. It is in this stage, that the user also specifies if buses will be considered separately to other heavy vehicles, which is required if bus priority treatments (such as bus lanes or B-lights) are in use at the considered intersection.

7.1.1.2. Intersection Geometry

The intersection geometry includes the input of the number of lanes and the lane properties. The lane properties include the width and length of the lane. It is important that this is input correct as it directly impacts the speed which vehicles travel through the intersection and, hence, also impacts queuing distances and delay times.

For each lane, movements are also specified, defining whether vehicles can travel left, through or right from the specified lane. This is specified for each vehicle type, as for bus lanes, the movement definitions would vary.

7.1.1.3. Pedestrian Data

The pedestrian data involves using the SCATS summaries to understand the minimum green time which is required for a pedestrian to cross the specified crossing. Whilst inputting this information, the user must also specify if the crossing is full (must cross both directions of traffic at once) or staged (can cross one direction of traffic, then stop on a centre median or island before crossing the other direction).

7.1.1.4. Traffic Volumes

The traffic volumes were required for the AM peak, PM peak, inter-peak and after-peak periods. The volumes are separated into vehicle classes: cars (light vehicles), CV's (commercial vehicles) and buses. It should be noted that the AM and PM peak hour period varied for each intersection, and was specified in the DPTI Turning Movement Surveys.

It was assumed that the inter-peak time period occurred between 10am and 3pm, and the after-peak period, occurred after the PM peak hour.

When deriving these volumes, many quantities were presented in 15 minute blocks, so for hourly periods (AM and PM peak) the appropriate quarter hour volumes were summed. For the inter and after-peak time intervals, as these usually spread over more than one hour, the average was taken per 15 minute period, then summed to provide an hourly average.

7.1.1.5. Traffic Signal Phasing

It was important that the phase sequences and phase times were correct, as this has a significant impact on the model output. The signal phases were derived from the DPTI's intersection drawings, and the timings and notes for each phase were provided in the SCATS Summaries.

This showed for each sequence, which vehicles were permitted to move through the intersection and any priority, filter or give-way movements. The green, yellow and red time was also specified for each phase. It should be noted that this varied for each time interval, to benefit peak traffic flows, and decrease delay time and queue length.

7.1.2. Detours Considered

Figure 156 below, shows the construction area, the intersections modelled and the three possible detour routes.

Figure 156 Detours and Intersections Modelled

Each detour specified was considered for the inter-peak and after-peak time intervals, in both the inbound and outbound) directions.

These routes were considered for detours as it was specified in the feasibility study that buses and other heavy vehicles utilise North Terrace, so the roads selected for detours, were required to have similar characteristics to those of North Terrace. This meant the selected routes had to meet minimum lane width requirements for buses and trucks to travel comfortably. The number of tight turns or small roundabouts which also had to be negotiated by large vehicles was minimised, and hence, resulted in some of the smaller, residential streets, been classed as inappropriate for use as a detour route.

7.1.3. Modelling Process

Once the possible detour routes had been defined, the modelling process was undertaken. This consisted of five key steps which are described in the following sections.

7.1.3.1. Data Collection

Prior to beginning any traffic modelling, the required data was collected from the DPTI. This involved retrieving approval from the appropriate personnel within the head office, and requesting the data from the Metropolitan Region group.

7.1.3.2. Base Model

Base models were created for each intersection which was analysed. A base model is used to replicate the current conditions, without the addition of extra volumes or traffic management infrastructure which would be implemented for detours.

The base model also uses the specified phase sequences and phase times as specified by the DPTI.

The base models are shown below in Figure 157, to *Figure 164*.

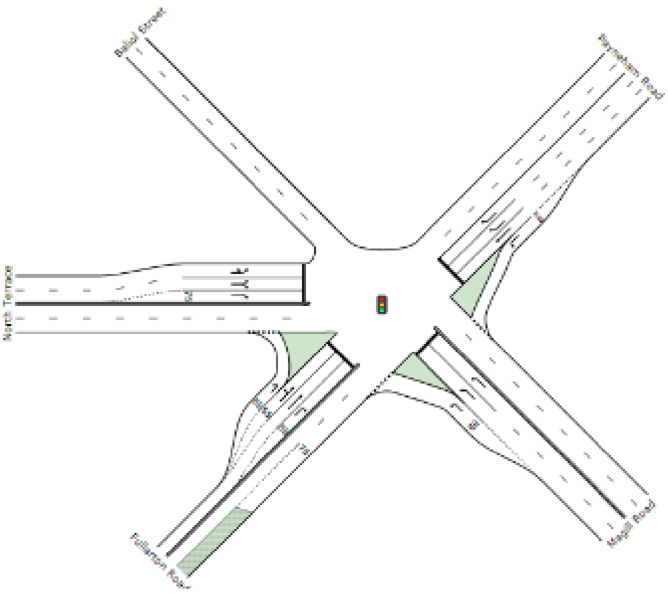

Figure 157 Fullarton Road-North Terrace Model

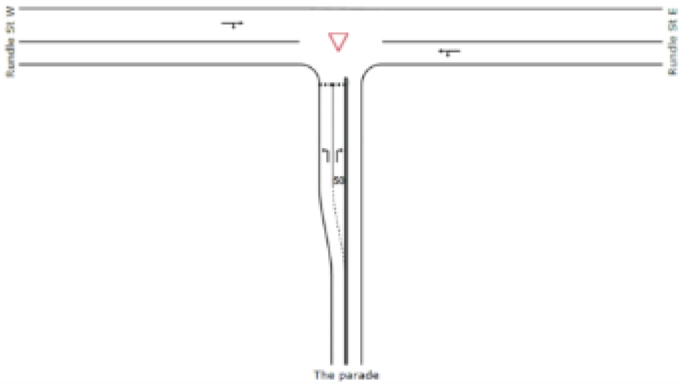

Figure 158 The Parade-Rundle Road Model

Fullarton Road-North Terrace

The Parade-Rundle Road

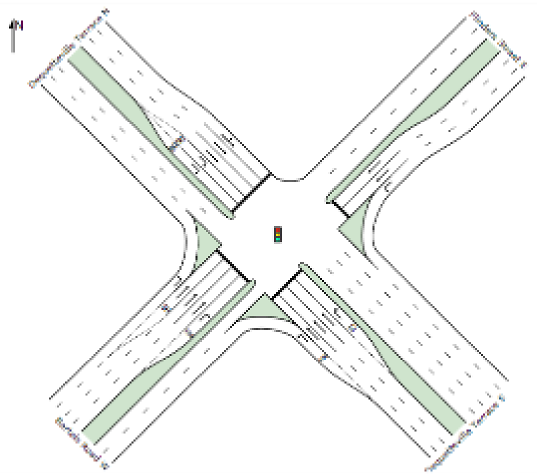

Figure 159 Dequetteville Terrace-Flinders Street Model

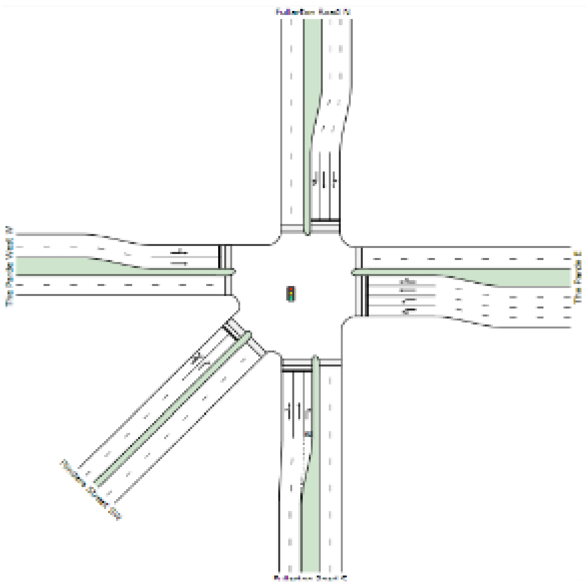

Figure 160 Fullarton Road-The Parade Model

Dequetteville Terrace-Flinders Street

Fullarton Road-The Parade

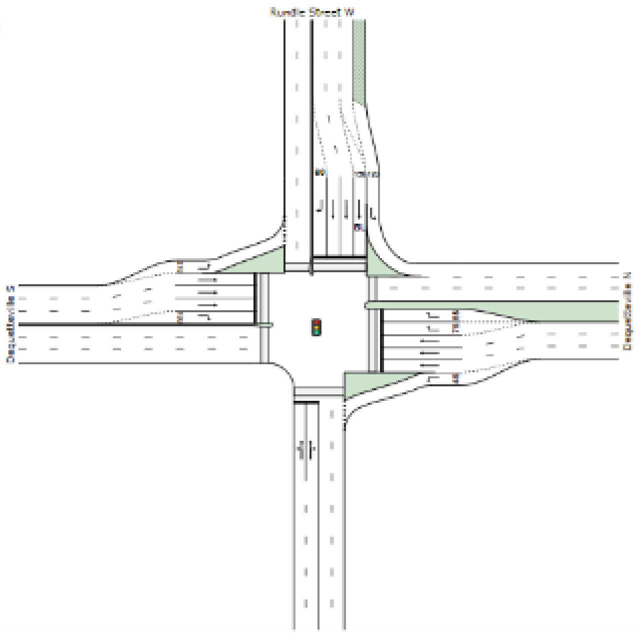

Figure 161 Rundle Road-Dequetteville Terrace Model

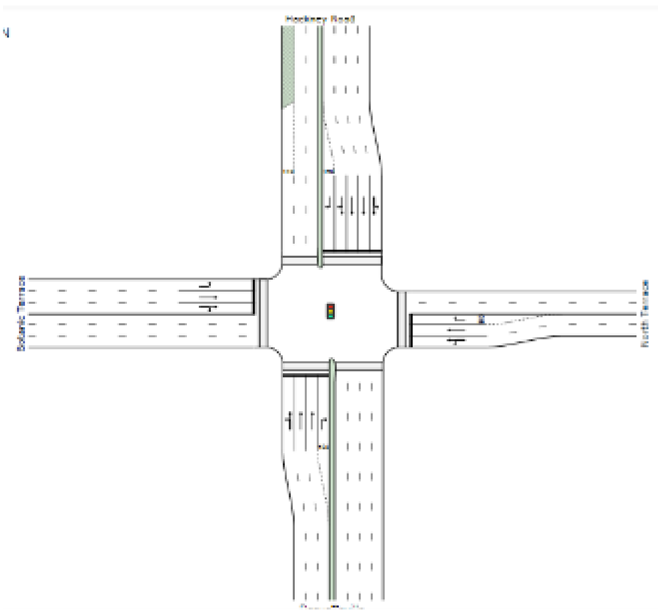

Figure 162 North Terrace-Hackney Road Model

Rundle Road-Dequetteville Terrace

North Terrace-Hackney Road

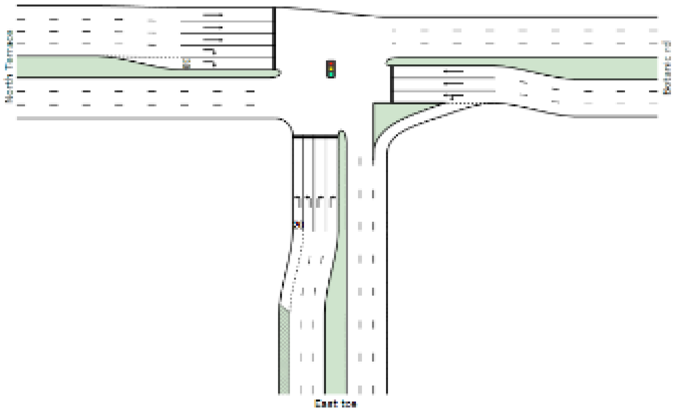

Figure 163 North Terrace-East Terrace Model

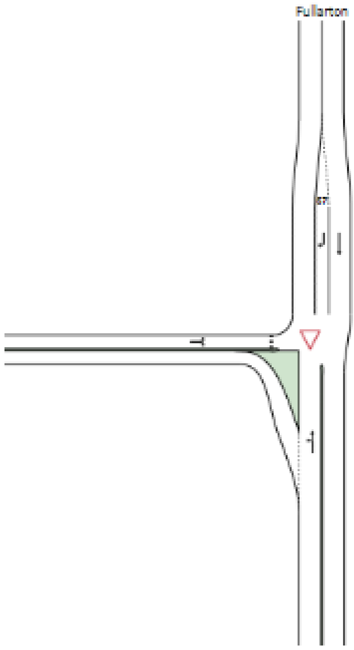

Figure 164 Fullarton Road-Rundle Road Model

North Terrace-East Terrace

Fullarton Road-Rundle Road

7.1.3.3. Detour Model

Detour models were then created with the addition of extra volumes and infrastructure. The volumes and infrastructure altered in the model are shown in Figure 165 to Figure 170. The numbers in the text boxes represent the additional volumes which were added to the volumes used at the specified intersection in the base model. The small traffic signal symbol also shows the addition of temporary traffic signals at the specified intersection.

Please note that Inter, represents the inter-peak additional volumes, and After, represents the after-peak additional volumes.

Figure 165: Detour Option 1-Inbound

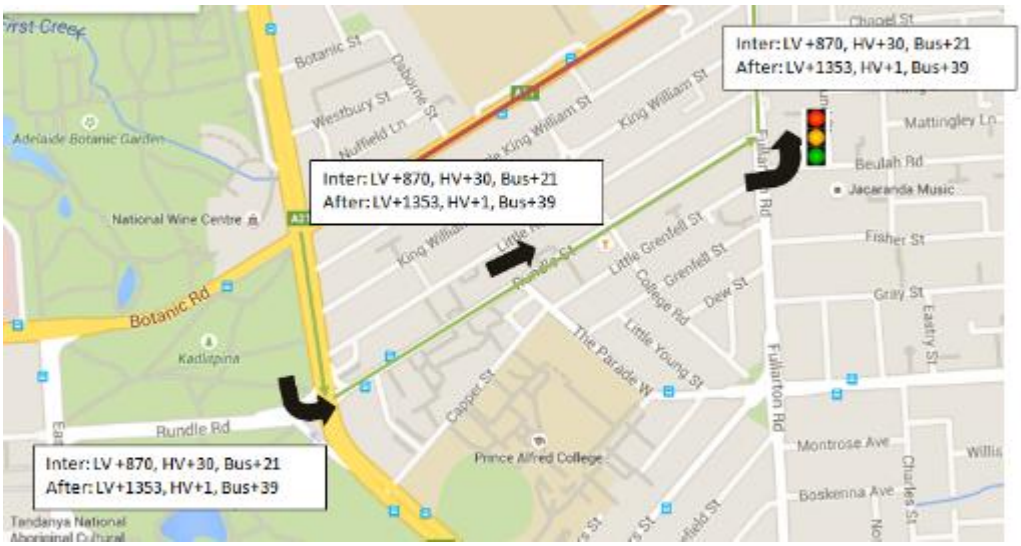

Figure 166 Detour Option 1-Outbound

Figure 167 Detour Option 2-Inbound

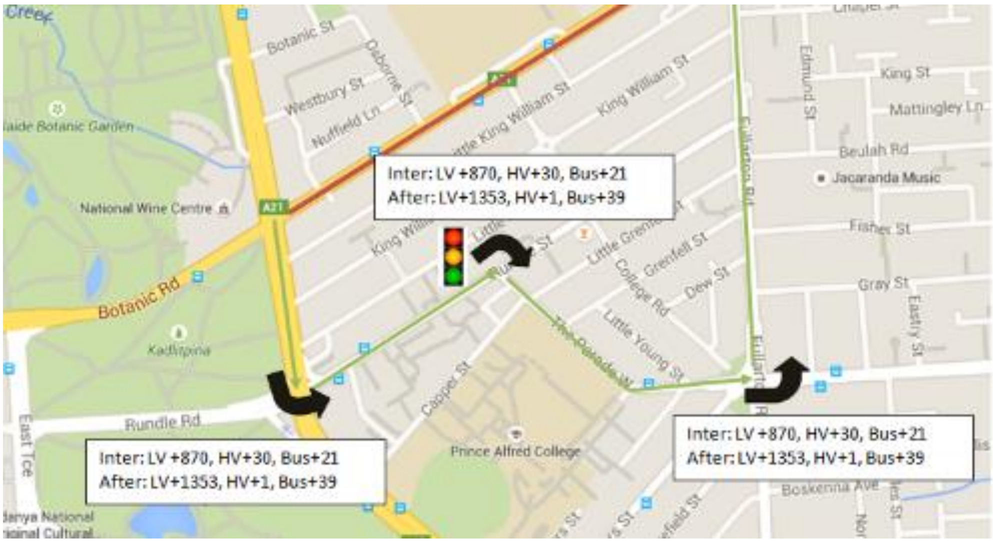

Figure 168 Detour Option 2-Outbound

Figure 169 Detour Option 3-Inbound

Figure 170 Detour Option 3-Outbound

The additional detour volumes were derived from the traffic models which were produced for the intersections which bordered the construction zone (Botanic Road/Hackney Road, and Fullarton Road/North Terrace/Magill Road/Payneham Road).

Whilst modelling the detours, it was assumed that if a full closure occurred within the construction zone, then 100% of the vehicles which leave or enter the zone, from the bordering intersections defined above, would use the detours.

Phase times were also altered in the detour models. The same phase sequences were used, but instead of modelling these with the current phase times provided by the DPTI, the optimum phase times were used. This is a modelling setting within SIDRA which will allocate amounts of green, yellow and red time to optimise traffic flow, dependent on traffic volumes.

In Figure 165, Figure 166, Figure 167 and Figure 168, the addition of temporary signals can also be noted. These were implemented on detour routes which contained unsignalised intersections, where traffic flow is currently controlled by give way signs. Though these will increase the cost of detour implementation, it will improve traffic flow with the additional traffic volumes.

7.1.3.4. Traffic Management within the Construction Zone

Within the construction zone, along North Terrace, modelling was also completed by simulating the bordering intersections. A base model was created for both the Hackney Road/North Terrace and North Terrace/Fullarton Road/Magill Road/Payneham Road intersections. Scenarios were then modelled to replicate lane closure combinations during construction work, and the results were analysed to understand how construction would impact the capacity of the intersection.

By completing this, it could be ensured that the bordering intersections would remain under, or at, capacity and not cause lengthy delays if lane closures were implemented. Modelling each scenario during different time intervals also highlighted the optimum time for each lane closure to be implemented.

The construction work closures which were modelled included:

- 1 lane closed outbound – Northern side
- 1 lane closed inbound– Southern side
- 2 lanes closed – One each side
- 2 lanes closed – Southern side

It should be noted that other traffic scenarios were considered, but were not modelled using the SIDRA software due to software limitations discussed in Section 7.1.8.

7.1.3.5. Analysis of Results

The results were then analysed for each detour option to select the most appropriate detour for inter-peak and after-peak time intervals, in the inbound and outbound direction.

The output used for this task was the movement summary produced by SIDRA. Within the movement summary the level of service, average delay and degree of saturation were noted for the average of the intersection (instead of analysing each individual arm).

The level of service is a letter representation of how well the intersection is performing. This ranges from A to F, where A is the most favourable. A better level of service represents shorter delay and queue lengths, indicating road users passing through the intersection quicker than the lower service scores.

The average delay is presented in seconds, and is the delay experienced by a road user, in a light vehicle, at that specific intersection.

The degree of saturation was the final criteria used to evaluate the efficiency of the intersection and represents the intersections capacity. Generally, a score under 0.9 indicates the intersection is under capacity, so could easily have more vehicles pass through the intersection, whilst maintaining efficiency. A score between 0.9 and 1.0 indicates the intersection is at capacity and greater than 1.0 is over capacity.

7.1.4. Summary and Analysis of Results-Detour Capacity

The results can be summarised, as seen in Table 62-Table 65. The current capacity results summarise the output from the base models, and the detour capacity is the output from the models created to replicate detour conditions.

It should be noted that unsignalised intersections, will output a level of service as NA.

The comments column summarises the ways which the base models were altered to replicate detour conditions.

Table 62 AM Peak SIDRA Output

AM Peak											
Intersection Number	Intersection	Current Capacity			Detour Capacity (Inbound)			Detour Capacity (Outbound)			Comments
		Level of Service	Degree of Saturation	Average Delay	Level of Service	Degree of Saturation	Average Delay	Level of Service	Degree of Saturation	Average Delay	
1	East Terrace-North Terrace	C	0.739	25.6							No detours considered during AM and PM Peak periods.
2	Fullarton Road-Rundle Street	NA	0.474	4.7							No detours considered during AM and PM Peak periods.
3	Rundle Street-The Parade West	NA	0.423	7.7							No detours considered during AM and PM Peak periods.
4	Dequetteville Terrace-Rundle Road	F	1.741	321.4							No detours considered during AM and PM Peak periods.
5	Dequetteville Terrace-Flinders Street	F	1.463	168.5							No detours considered during AM and PM Peak periods.
6	Fullarton Road-The Parade West	F	1.495	216.6							No detours considered during AM and PM Peak periods.

Table 63 PM Peak SIDRA Output

PM Peak											
Intersection Number	Intersection	Current Capacity			Detour Capacity (Inbound)			Detour Capacity (Outbound)			Comments
		Level of Service	Degree of Saturation	Average Delay	Level of Service	Degree of Saturation	Average Delay	Level of Service	Degree of Saturation	Average Delay	
1	East Terrace-North Terrace	C	0.712	22.7							No detours considered during AM and PM Peak periods.
2	Fullarton Road-Rundle Street	NA	0.747	4.9							No detours considered during AM and PM Peak periods.

3	Rundle Street-The Parade West	NA	0.431	6.9							No detours considered during AM and PM Peak periods.
4	Dequetteville Terrace-Rundle Road	D	1.049	53.2							No detours considered during AM and PM Peak periods.
5	Dequetteville Terrace-Flinders Street	F	1.301	146.9							No detours considered during AM and PM Peak periods.
6	Fullarton Road-The Parade West	F	1.138	156.8							No detours considered during AM and PM Peak periods.

Table 64 Inter-Peak SIDRA Output

Inter Peak											
Intersection Number	**Intersection**	**Current Capacity**			**Detour Capacity (Inbound)**			**Detour Capacity (Outbound)**			**Comments**
		Level of Service	**Degree of Saturation**	**Average Delay**	**Level of Service**	**Degree of Saturation**	**Average Delay (seconds)**	**Level of Service**	**Degree of Saturation**	**Average Delay (seconds)**	
1	East Terrace-North Terrace	B	0.468	13.7							Detour capacity checked for extension of detour
2	Fullarton Road-Rundle Street	NA	0.333	2.8	Detour 1:F	Detour 1: 2.19	Detour 1: 1247.5	Detour 1:F	Detour 1: 2.19	Detour 1: 166.8	Not signalised, analyse detour capacity with extra volumes and also with addition of temporary signals
3	Rundle Street-The Parade West	NA	0.248	6.2	Detour 1: F Detour 2: F	Detour 1: 1.869 Detour 2: 1.265	Detour 1: 414.4 Detour 2: 476.6	Detour 1: C Detour 2: F	Detour 1: 0.932 Detour 2: 1.358	Detour 1: 28.8 Detour 2: 600.1	Not signalised, analyse detour capacity with extra volumes and also with addition of temporary signals

4	Dequetteville Terrace-Rundle Road	D	0.769	35.1	Detour 1: F Detour 2: F	Detour 1: 2.041 Detour 2: 2.041	Detour 1: 817.8 Detour 2: 817.8	Detour 1: C Detour 2: C	Detour 1: 0.881 Detour 2: 0.881	Detour 1: 32.4 Detour 2: 32.4	Already signalised and can perform RH turn from Rundle Street to Dequetteville Terrace. Detour capacity analysed with extra volumes and altered phasing
5	Dequetteville Terrace-Flinders Street	C	0.722	27.0	Detour 3: F	Detour 3: 1.646	Detour 3: 694.6	Detour 3: F	Detour 3: 1.503	Detour 3: 518.2	Already signalised, no right turns, extra volume and right turns enabled for detour capacity analysis
6	Fullarton Road-The Parade West	D	0.610	36.3	Detour 2: F Detour 3: F	Detour 2: 1.592 Detour 3: 1.478	Detour 2: 693.8 Detour 3: 555.9	Detour 2: F Detour 3: F	Detour 2: 1.152 Detour 3: 1.169	Detour 2: 170.4 Detour 3: 202.0	Already singalised, extra voume added for detour capacity analysis

Table 65 After-Peak SIDRA Output

After Peak											
Intersection Number	Intersection	Current Capacity			Detour Capacity (Inbound)			Detour Capacity (Outbound)			Comments
		Level of Service	Degree of Saturation	Average Delay	Level of Service	Degree of Saturation	Average Delay	Level of Service	Degree of Saturation	Average Delay	
1	East Terrace-North Terrace	B	0.488	15.3							Detour capacity checked for extension of detour
2	Fullarton Road-Rundle Street	NA	0.552	3.4	Detour 1: F	Detour 1: 2.633	Detour 1: 1517.7	Detour 1: F	Detour 1: 1.455	Detour 1: 689.4	Not signalised, analyse detour capacity with extra volumes and also with addition of temporary signals
3	Rundle Street-The Parade West	NA	0.235	5.5	Detour 1: F Detour 2: F	Detour 1: 1.539 Detour 2: 1.127	Detour 1: 268.9 Detour 2: 278.3	Detour 1: E Detour 2: F	Detour 1: 0.991 Detour 2: 1.720	Detour 1: 55.1 Detour 2: 1237.9	Not signalised, analyse detour capacity with extra volumes and also with addition of temporary signals

4	Dequetteville Terrace-Rundle Road	C	0.846	34.9	Detour 1: F Detour 2: F	Detour 1: 2.609 Detour 2: 2.609	Detour 1: 872.1 Detour 2: 872.1	Detour 1: F Detour 2: F	Detour 1: 1.265 Detour 2: 1.251	Detour 1: 205.2 Detour 2: 199.1	Already signalised and can perform RH turn from Rundle Street to Dequetteville Terrace. Detour capacity analysed with extra volumes and altered phasing
5	Dequetteville Terrace-Flinders Street	C	0.999	30.9	Detour 3: F	Detour 3: 1.439	Detour 3: 496.0	Detour 3: F	Detour 3: 1.181	Detour 3: 226.6	Already signalised, no right turns, extra volume and right turns enabled for detour capacity analysis
6	Fullarton Road-The Parade West	D	0.917	46.8	Detour 2: F Detour 3: F	Detour 2: 1.557 Detour 3: 1.461	Detour 2: 810 Detour 3: 664	Detour 2: F Detour 3: F	Detour 2: 1.620 Detour 3: 1.652	Detour 2: 786.4 Detour 3: 762.6	Already singalised, extra voume added for detour capacity analysis

7.1.5. Appropriate Detour Routes

As can be seen in the above results, it is clear that some routes would not be appropriate for use as detours, as the capacity of the intersection is already at, or over, the recommended capacity. This can be seen by many intersections exceeding the recommended degree of saturation, which is between 0.9 and 1.0, in both the inter-peak and after-peak periods.

Though not included in any current detour routes, the intersection of East Terrace and North Terrace was also modelled. As this intersection lies just outside the construction zone, it is important to understand this intersection's current capacity. The results show that this intersection is under capacity during each time interval. Therefore, if during construction, any detours were required to be extended for a length to allow for machinery or material placement, the contractors could consider shutting this intersection, or lanes within this intersection, without having a significant impact on traffic.

The AM and PM peak results also highlight the fact that implementing full closures, which require detours during the peak periods is inappropriate, as during these time intervals the intersections are significantly busier, and perform much more poorly.

These results were then used to define the most appropriate detour routes, by taking the average of each degree of saturation, for the intersections which would carry the extra capacity during the detours. The outcomes of this are shown below:

Table 66 Selected Detour Routes

Detour Name	Average Degree of Saturation (Inter-peak, Inbound)	Average Degree of Saturation (Inter-peak, Outbound)	Average Degree of Saturation (After-peak, Inbound)	Average Degree of Saturation (After-peak, Outbound)
Detour 1 **-Fullarton Road/Rundle Road** **-Rundle Road/The Parade** **-Rundle Road/Dequetteville Terrace**	2.03	1.33	2.26	1.24
Detour 2 **-Fullarton Road/The Parade** **-The Parade/Rundle Road** **-Rundle Road/Dequetteville Terrace**	1.63	1.13	1.76	1.53
Detour 3 **-Fullarton Road/Flinders Street** **-Flinders Street/Dequetteville Terrace**	1.56	1.34	1.45	1.42

In Table *66* above, the cells highlighted in grey show the route which is most appropriate for the selected detour. The appropriateness of the route was based on the degree of saturation of the relevant intersections, once the required extra volumes and infrastructure had been added to the existing conditions and traffic flow.

7.1.6. Implementation of Detours

Though detours have been selected for the inter-peak and after-peak period, it is likely that the only detours which will be implemented are the after-peak routes. The modelling completed as part of this design highlights the importance of maintaining the road's function during the day (inter-peak period).

It may be useful during construction to know which detours are most appropriate for the inter-peak time interval though, in case they are required if the project runs overtime and full closures are implemented during this time period.

The detours will be implemented, using the standard work zone traffic management setups, defined by the Government of South Australia's Department of Planning, Transport and Infrastructure Field Guide (DPTI, 2012). Please see Section 7.4.4 for details of how these will be setup.

7.1.7. Summary and Analysis of Results-Capacity within the Construction Zone

Following the same process as described in Section 7.1.3, modelling was also undertaken within the construction area. The purpose of this was to understand how the road's capacity, and length of delay, would change as different combinations of lane closures were implemented.

Whilst modelling these, typical closures were considered. As mentioned, contra-flow was not modelled due to its limitations in the software (regarding speed restrictions and traffic movements). Though this scenario was not modelled, the contra-flow traffic setup was still considered, and traffic management plans for this can be found in Section 7.4.3.

Intersection	Current Capacity			Description of Closure	Capacity During Construction Closures		
	Delay (sec)	Level of Service	Degree of Saturation		Delay (sec)	Level of Service	Degree of Saturation
Hackney Road/North Terrace (AM)	109.0	F	1.463	1 lane closed –outbound lane	113.6	F	1.463
				1 lane closed-inbound lane	520.0	F	1.920
				2 lanes closed (one on each side)	548.4	F	1.920

			2 lanes closed (both closed on inbound side-with optimum phasing)	1067.5	F	2.074
Hackney Road/North Terrace (PM)	110.7	F	1.14	1 lane closed-outbound	405.7	F	1.849
				1 lane closed-inbound lane	147.5	F	1.14
				2 lanes closed (one on each side)	300.9	F	1.543
				2 lanes closed (both closed on inbound side-with optimum phasing)	805.9	F	1.680
Hackney Road/North Terrace (Inter-peak)	39.8	D	0.915	1 lane closed-outbound	87.5	F	1.221
				1 lane closed-inbound lane	138.4	F	1.249
				2 lanes closed (one on each side)	186.4	F	1.249
				2 lanes closed (both closed on inbound side-with optimum phasing)	572.5	F	1.454
North Terrace /Fullarton Road (AM)	110.3	F	1.186	1 lane closed Northern side	233.7	F	1.704
				1 lane closed Southern side	397.0	F	1.861
				2 lanes closed (one on each side)	520.4	F	1.861
North Terrace/ Fullarton Road (PM)	160.2	F	1.216	1 lane closed Northern side	463.5	F	1.786
				1 lane closed Southern side	252	F	1.424
				2 lanes closed (one on each side)	555.2	F	1.786
North Terrace/ Fullarton Road (Inter-peak)	36.6	D	0.839	1 lane closed Northern side	52.7	D	1.031
				1 lane closed Southern side	94.8	F	1.191
				2 lanes closed (one on each side)	111	F	1.191

Table 67 summarises the output for lane closures within the construction zone.

Table 67 Capacity for Lane Closures in Construction Zone

Intersection	Current Capacity			Description of Closure	Capacity During Construction Closures		
	Delay (sec)	Level of Service	Degree of Saturation		Delay (sec)	Level of Service	Degree of Saturation
Hackney Road/North Terrace (AM)	109.0	F	1.463	1 lane closed –outbound lane	113.6	F	1.463
				1 lane closed-inbound lane	520.0	F	1.920
				2 lanes closed (one on each side)	548.4	F	1.920
				2 lanes closed (both closed on inbound side-with optimum phasing)	1067.5	F	2.074
Hackney Road/North Terrace (PM)	110.7	F	1.14	1 lane closed-outbound	405.7	F	1.849
				1 lane closed-inbound lane	147.5	F	1.14
				2 lanes closed (one on each side)	300.9	F	1.543
				2 lanes closed (both closed on inbound side-with optimum phasing)	805.9	F	1.680
Hackney Road/North Terrace (Inter-peak)	39.8	D	0.915	1 lane closed-outbound	87.5	F	1.221
				1 lane closed-inbound lane	138.4	F	1.249
				2 lanes closed (one on each side)	186.4	F	1.249
				2 lanes closed (both closed on inbound side-with optimum phasing)	572.5	F	1.454
North Terrace /Fullarton Road (AM)	110.3	F	1.186	1 lane closed Northern side	233.7	F	1.704
				1 lane closed Southern side	397.0	F	1.861
				2 lanes closed (one on each side)	520.4	F	1.861
North Terrace/ Fullarton Road (PM)	160.2	F	1.216	1 lane closed Northern side	463.5	F	1.786
				1 lane closed Southern side	252	F	1.424
				2 lanes closed (one on each side)	555.2	F	1.786
North Terrace/ Fullarton Road (Inter-peak)	36.6	D	0.839	1 lane closed Northern side	52.7	D	1.031
				1 lane closed Southern side	94.8	F	1.191
				2 lanes closed (one on each side)	111	F	1.191

The results of the above table reflect typical degrees of saturation and delay times, for the traffic management layouts described in each scenario. As can be seen, the overall impact to traffic is minimised if these closures are implemented during the inter-peak period. It can be assumed that the after-peak results would be very similar to the inter-peak period due to reduced traffic volumes. After-peak conditions were not modelled as it was assumed that most works scheduled during the after-peak period could be completed during the full closure, when the detour is implemented.

It can also be noticed that if single lane closures are required in the AM or PM peak period, then the impact to traffic is minimised if the closures are setup for the counter-peak direction (e.g. it is more beneficial to close an outbound lane in the AM peak, as greater volumes of traffic are travelling inbound, to the CBD).

Upon the commencement of construction, these results would be presented to the contractors, to ensure traffic flows under optimum conditions at all times and delay is minimised.

7.1.8. Limitations of Traffic Modelling

Using SIDRA as a traffic modelling tool to determine current intersection capacity, and observe how this would alter with the addition of infrastructure and increased volumes for a detour was very useful. There are limitations in this work though, that should be noted. These include:

- Contra-flow Traffic Modelling – It is not possible to create a model in SIDRA which correctly models contra-flow traffic conditions, due to limitations in the software which require at least 1 exit lane for the model to process. Therefore, the true impact of setting up a workzone which utilises contra-flow is unknown.
- Connection of Intersections – Each intersection was modelled independent of surrounding intersections. This is likely to have little impact on the results, but in sections of road where traffic phases are linked, the results are a less accurate representation of the field conditions.
- After-peak Traffic Volumes – Traffic count data was provided by the DPTI, which showed the volumes of traffic passing through the intersection, in 15 minute blocks. Unfortunately, this data is only recorded until 7pm. Therefore, the after-peak volumes were based on the average volume count between the end of the intersections PM peak and 7pm. This means that the results for the after-peak period are conservative, as it is known that volumes later in the night (eg. between midnight and 2pm) are significantly lower than between 6pm and 7pm.

7.2. Pedestrian and Business Access

In this design, pedestrian safety and pedestrian access was of prime importance. As described in the above sections, vehicle traffic was analysed, but it was also vital to consider the effect which construction would have on other road users.

7.2.1. Separation between Pedestrians and Construction Areas

North terrace construction needs to not inhibit pedestrian access, and it is the responsibility of the traffic management team to ensure a sufficient barrier is provided, to separate construction works from footpaths and walkways. The tools used to protect pedestrians during construction, should be assessed by the onsite manager with consideration from this design.

It is recommended that temporary fences or plastic traffic barriers should be used to create a physical barrier between workers and their machinery and the public. Please see Section 7.4.5 which details the placement of these barriers, and also details the location of other required signage.

7.2.2. Footpath Access

The footpath walkway also has certain standards that need to be adhered to at all times. These standards include providing ease of access for wheelchair users and walkers, with a minimum footpath width of 1.5m. The footpath must also be smooth and free of debris, to avoid creating slip/trip hazards in the work zone. As well as appropriate signage, connectivity ramps must also be provided at kerbs and steel sheeting must be used to cover exposed holes. There may be no other obstructions within the pedestrian access area.

In cases that lane closures also require the closure of the pavement, pedestrians will be encouraged to use the footpath on the alternate side of the road. If this occurs, a safe area for crossing will be setup with the appropriate traffic control measures.

Full closures are also likely to be implemented, but in this case, pedestrian detours will be provided. Please see Section 7.4.5 for details of these detours.

7.2.3. Pedestrian Access to the School and Pedestrian Crossings

An area of great importance is the school which is located on North Terrace. It is known that construction will occur during the school holidays, so pedestrian traffic into this area should not be excessive. Access to this area is still required though, as parents, teachers or students may need to visit the school for community events or school related meetings.

Therefore, access to this location needs to be provided during all business hours, not only the peak times for a school i.e. (Monday-Friday, 8am to 9am and 3pm to 4pm). During business hours it must be ensured that pedestrians can access and cross the road with fair visibility and safety. Located in the NE direction, from the school carpark exit, is a pedestrian crossing. The construction team will ensure that impact to this crossing is minimal, and that the crossing is open during all stages of the project, within business hours. Please see Figure 171 for location of these crossings, in relation to the location of the school.

If the school pedestrian crossing (also highlighted in Figure 171), is to be impacted during business hour construction, the traffic management team will provide an alternate crossing area, which can be operated by traffic management workers, using a Stop/Slow bat. This ensures safety and ease of accessibility for pedestrians. The two other pedestrian crossings in the construction area, are unlikely to be impacted as they are located at the two intersections which border the construction zone (Hackney Road/North Terrace and Fullarton Road/North Terrace), and an aim during construction is to setup work zone traffic management plans, which leave these major intersections fully functional.

Figure 171 Locations of Pedestrian Crossings and Local School

7.2.4. Pedestrian Access during Full Closures-Night Works

Due to the nature and limited visibility of pedestrians during night works, it is proposed that pedestrian access between North Terrace and Dequetteville Terrace is blocked, whilst night works are undertaken. All properties that shall be affected during the time of construction (After-Peak,) that will require pedestrian access, will follow alternate access routes defined in Section 7.2.6

7.2.5. Business Operating Hours

Construction work should also have minimum impact to local businesses, even when road closures are in effect. To understand the optimum timing for closures, and alternate access routes for businesses, Table 68 was created. This summarises the operating hours for each business, whether access is required during after-peak hours and proposed alternate access routes, it also notes the location of residential allotments.

Business Name	Normal Operating Hours	After-peak Access Needed	Alternate Vehicle Access
Royal Hotel (2 North Terrace)	10am-4am	Yes	Little King William Street
Hackney Gourmet Café & Snack Bar (19 North Terrace)	Not specified	No	Nuffield Lane via Westbury Street
Accede Holdings (23 North Terrace)	9am-5pm	No	Nuffield Lane
Hickinbotham Group Office (25 North Terrace)	8:30am-5:30pm	No	Nuffield Lane
Hickinbotham Building (Warehouse) (20 North Terrace)	Not specified	Yes*	Little King William Street
Satisfaction (33 North Terrace)	11am-6pm	Yes	Nuffield Lane via Westbury Street
Camp Gallipoli (35 North Terrace)	Not specified	No	Nuffield Lane via Westbury Street
31, 37, 39, 41, 45, 47, 49, 51 North Terrace (Residential)	All hours access	Yes	Nuffield Lane via Westbury Street- rear property access
Passport Eyeware (43 North Terrace)	9am-5pm	No	Osborne Street or Nuffield Lane
Eklektic Furniture & Homewares	Not specified	Yes*	Little King William Street
Gleeson Agencies (53 North Terrace	8:30am-4:30pm	No	Osborne Street
North Terrace Tyres (55-57 North Terrace)	9am-5pm	No	Osborne Street

Clark Rubber (30 North Terrace)	9am-5:30pm	Yes*	Little King William Street
Adelaide Heart Clinic (32 North Terrace)	Not specified	Yes*	Little King William Street
Big Wig (59 North Terrace)	8:30am-5pm	No	Osborne Street or Nuffield Lane
Prince Alfred College	7am-5pm	Yes	Trinity Street to Wyandra Lane or Hackney Road to Wyandra Lane
34-46 North Terrace (Residential)	All hours access	Yes	Little King William Street

Table 68 Business Operating Hours and Business/Residential Alternate Access Routes

* Delivery Requirements

7.2.6. Business and Residential Access

Ease of access will be provided to these residential areas and businesses, through the development of traffic management plans that will ensure the impact to usual access routes is minimal to pedestrian and vehicle traffic. In the case of a full road closure or lane closure, outside the specified business or home, alternate access will be provided. The alternate access routes are also listed in the table above.

The alternate access routes provide extra parking areas for business users and most provide rear access to the property. This ensures that local businesses are able to remain operating efficiently. Fortunately for most of the homes and businesses in the area, the carport, garage or entry, is located at the rear of the property, so construction works will not have a large impact on access.

As can also be seen in Table 68, most businesses operate during the peak and interpeak periods. This provides more reasoning for the full closure and detours to be implemented during the after peak period and for night works to commence.

7.2.7. Road Closure Notice

In order to keep all property owners and businesses content, and supportive of the construction works, there will be an early notification sent out to those who are located within the construction area.

There will also be a notice of proposed road closure produced, which will be placed in both the Advertiser and Sunday Mail. In addition to this, a letter drop will be conducted to inform local businesses and residents of the works, and provide the opportunity for these people to notify the construction team of special requests or have any queries answered.

An example of the road closure notice and letter drop is displayed in Appendix, Section 0.

In addition to the public notifications, there will also be notifications provided to the emergency departments; MFS, SA Health, SAPOL and DPTI.

7.3. Public Transport Impacts

Due to its close proximity to the CBD, this road is known to be frequently accessed as a public transport corridor for Adelaide Metro buses. During the design stage, considering the relocation of stops and detour routes for public transport was vital. To notify bus patrons of the stop relocation, a poster was also designed which would be displayed on local bus stops and on the Adelaide Metro website.

7.3.1. Routes

The first step in analysing how the construction work would impact public transport involved analysing the bus services which utilised the stops located within the construction zone, and noting the times which these stops were serviced by that particular route.

7.3.1.1. Stop 2 North Tce – North West side (35 North Terrace)

The first stop analysed was stop 2, on the North-Western Side of North Terrace. This stop is highlighted in Figure 172, below.

Figure 172 Stop 2 North Terrace, Outbound

The routes which service this stop, and the times which the stops are utilised are shown in Table 69.

Table 69 Operating Hours of Busses Servicing Stop 2, Outbound

Route (Monday-Friday)	Time
174	06:29 AM – 11:30 PM
176, 178,176G, 178M, 178S& 178X	06:29 AM – 12:30 AM
B10, B10X	06:20 AM – 12:14 AM
H30, X30, H30S &X30S	05:58 AM – 11:58 PM
H33, H33C	07:15 AM – 11:28 PM
W90, W91 &W90M	06:08 AM – 12:02 AM
Route (Saturday)	Time
174	07:50 AM – 11:43 PM
178, 178S	08:05 AM – 11:31 PM
B10	07:44 AM – 12:15 AM
H30, H30S	07:12 AM – 11:59 PM
H33	09:28 AM – 11:29 PM
W90, W91 &W90M	07:22 AM – 11:45 PM
AO11	10:07 PM – 10:37 PM
AO12	10:06 PM – 10:46 PM
Route (Sunday& Public holidays)	Time
174	08:50 AM – 11:43 PM
178, 178S	09:05 AM – 11:31 PM
B10	08:44 AM – 11:15 PM
H30, H30S	08:42 AM – 11:59 PM
H33	09:28 AM – 11:29 PM
W90, W91 &W90M	08:52 AM – 11:45 PM
Route (Saturday PM-Sunday AM late night)	Time
N178	12:16 AM – 04:16 AM

Stop 2 North Tce – South East side (40 North Terrace)

Next the same stop, but on the South Eastern side was analysed. This stop is located almost opposite Stop 2, on the Western side as shown in Figure 173.

Figure 173 Stop 2 North Terrace, Inbound

Following this, the routes servicing this stop and times were identified in Table 70.

Table 70 Operating Hours of Busses Servicing Stop 2 North Terrace, Inbound

Route (Monday-Friday)	Time
174	05:46 AM – 11:25 PM
176, 178, 178A &178X	06:16 AM – 11:09 PM
B10, B10C	05:46 AM – 11:51 PM
H30, X30 &H30C	06:01 AM – 12:13 AM
H33, H33C	06:16 AM – 08:55 PM
W90, W91	05:49 AM – 11:20 PM
626	04:12 PM
630	04:03 PM – 04:47 PM
638	03:46 PM
Route (Saturday)	Time
174	07:09 AM – 11:10 PM
178	06:44 AM – 12:54 AM
B10	06:58 AM – 11:53 PM
H30	07:00 AM – 10:42 PM
H33C	07:13 AM – 12:12 AM

W90, W91	07:47 AM – 11:07 PM
AO11	05:11 PM – 06:31 PM
AO12	05:20 PM – 06:30 PM
Route (Sunday & Public holidays)	Time
174	08:39 AM – 11:10 PM
178	08:44 AM – 11:24 PM
B10	08:28 AM – 11:53 PM
H30	08:30 AM – 10:42 PM
H33C	09:13 AM – 12:12 AM
W90, W91	08:47 AM – 11:07 PM
Route (Sarurday PM- Sunday AM late night)	Time
178, N178	01:01 AM – 3:54 AM

7.3.1.2. Stop 3 North Tce – North West side (75-81 Saint Peter's College)

Stop 3 was then analysed. As highlighted in Figure 174, this is located outside the school, but may not be serviced as frequently during construction, due to the school holiday period.

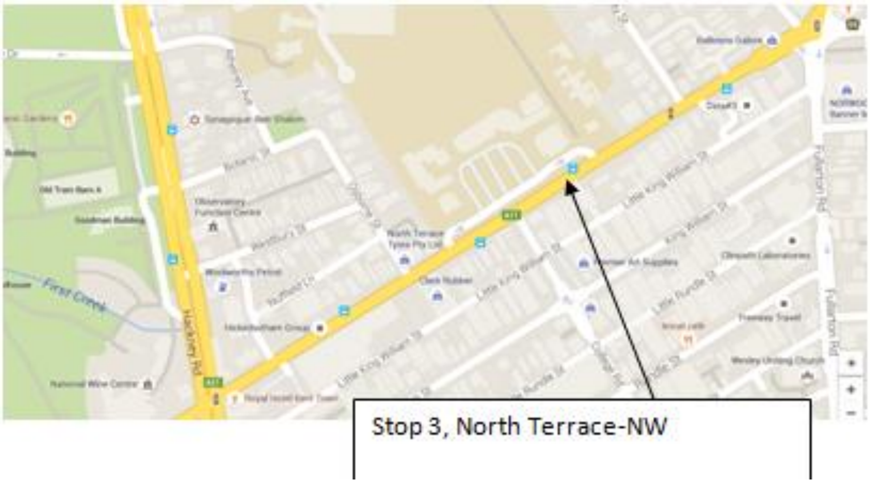

Figure 174 Stop 3 North Terrace, Outbound

Table 71 Operating Hours of Busses Servicing Stop 3, Outbound

Route (Monday-Friday)	Time
174	06:30 AM – 11:31 PM
176, 178,176G, 178M, 178S	06:30 AM – 12:31 AM
B10	06:21 AM – 12:15 AM
H30, X30, H30S &X30S	05:59 AM – 11:59 PM
H33	07:15 AM – 11:28 PM
W90, W91 &W90M	06:09 AM – 12:03 AM
Route (Saturday)	Time
174	07:50 AM – 11:43 PM
178, 178S	08:06 AM – 11:32 PM
B10	07:45 AM – 12:16 AM
H30, H30S	07:13 AM – 12:00 AM
H33	09:29 AM – 11:30 PM
W90, W91 &W90M	07:23 AM – 11:45 PM
AO11	10:09 PM – 10:49 PM
AO12	10:07 PM – 10:47 PM
Route (Sunday& Public holidays)	Time
174	08:50 AM – 11:43 PM
178, 178S	09:06 AM – 11:32 PM
B10	08:45 AM – 11:16 PM
H30, H30S	08:43 AM – 12:00 AM
H33	09:29 AM – 11:30 PM
W90, W91 &W90M	08:53 AM – 11:45 PM
Route (Saturday PM – Sunday AM late night)	Time
N178	12:17 AM – 04:12 AM

7.3.1.3. Stop 3 North Tce – South East side (82 North Terrace)

Figure 175 shows the location of Stop 3, South-Eastern side.

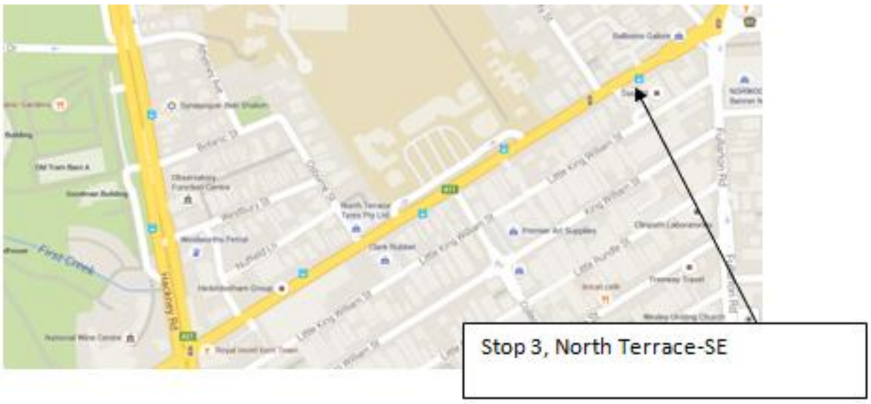

Figure 175 Stop 3, Inbound

The following table, shows the details for Stop 3, SE.

Table 72 Operating Hours of Busses Servicing Stop 3, Inbound

Route (Monday-Friday)	Time
174	05:45 AM – 11:25 PM
176, 178	06:16 AM – 11:09 PM
B10, B10C	05:46 AM – 11:51 PM
H30, X30 &H30C	06:01 AM – 12:13 AM
H33, H33C	06:15 AM – 08:55 PM
W90, W91	05:47 AM – 11:18 PM
626	04:12 PM
630	04:02 PM – 04:46 PM
638	03:44 PM
Route (Saturday)	Time
174	07:09 AM – 11:10 PM
178	06:44 AM – 12:54 AM
B10	06:57 AM – 11:53 PM
H30	06:59 AM – 10:42 PM
H33C	07:13 AM – 12:12 AM
W90, W91	07:46 AM – 11:05 PM
AO11	05:09 PM – 06:29 PM
AO12	05:19 PM – 06:29 PM

Route (Sunday & Public holidays)	Time
174	08:39 AM – 11:10 PM
178	08:44 AM – 11:24 PM
B10	08:27 AM – 11:53 PM
H30	08:29 AM – 10:42 PM
H33C	09:12 AM – 12:12 AM
W90, W91	08:46 AM – 11:05 PM
Route (Saturday PM – Sunday AM late night)	Time
178, N178	01:00 AM – 3:53 AM

7.3.2. Temporary Bus Stop

During the detailed design stage it was found that the type of bus stops located along the detour routes, are classed as intermediate stops. The stops are given this classification as they are located in an area which has a moderate passenger demand and a moderate frequency bus service (30 minutes for daily services). These stop types are predominantly located in suburban areas.

It must be ensured that any temporary stops provide the same supporting components as the existing stops. This includes appropriate bus stop signs, shelters, timetables, routes, seats and bins. Temporary stop locations must also consider the distance pedestrians would be expected to walk to access the stop.

7.3.2.1. Inbound: Existing and Temporary Stop

As North Terrance will be utilized as a construction area, the original inbound bus stops on North Terrance (described and located in Section 7.3.2), may not be able to be utilized by bus patrons.

Through traffic modeling it was found that traffic flowing inbound from Payneham Road and Magill Road will be using the detour which follows Fullarton Road, Flinders Road and Dequetteville Terrace. It can be assumed that the bus will follow this same detour, as shown in Figure 176. This also shows the location of existing inbound stops on the detour route-shown by the blue bus stop sign.

To ensure bus patrons do not significantly increase their walking distance when alighting from the service, three temporary bus stops will be constructed. These will be located on Fullarton Road, Flinders Street and Dequetteville Terrace, also shown on Figure 176 and represented by the red bus stop signs.

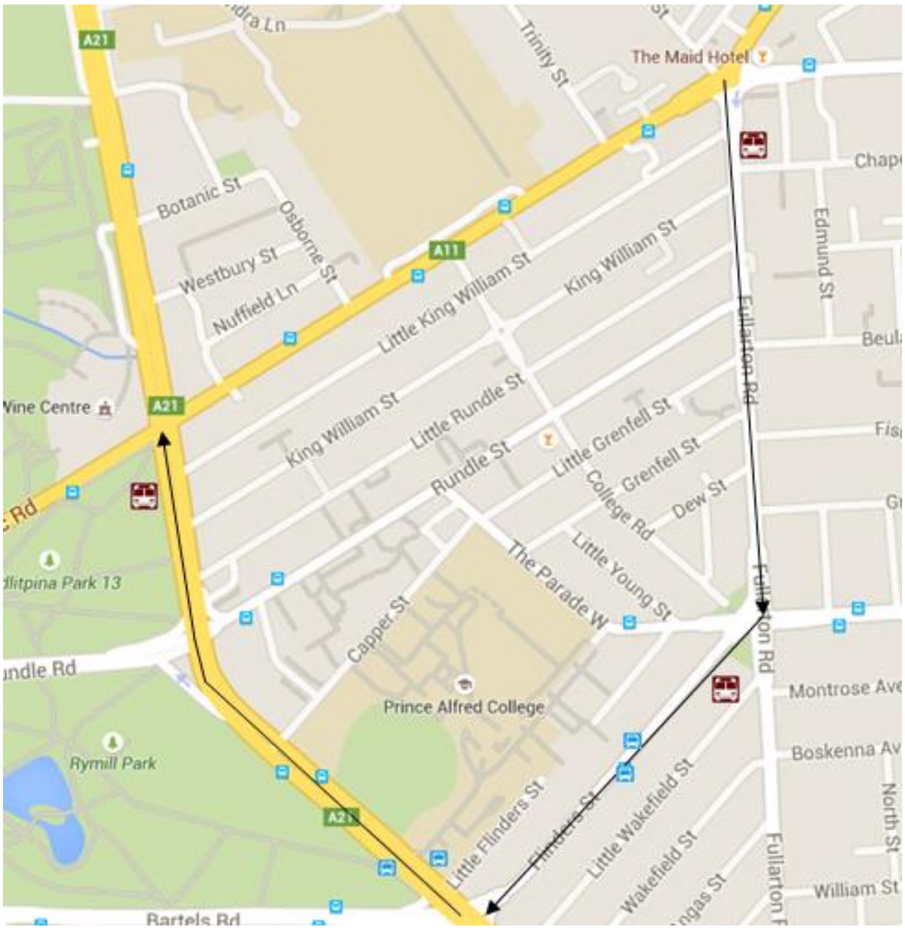

Figure 176 Inbound Detour, Existing and Temporary Stops

As found in the modeling section of this design, the inbound detour is the same for both inter-peak and after-peak routes, so it can be assumed that the same stops are used during both time periods.

7.3.3. Outbound

The modelling section of this report found that the detour route most suitable for the inter-peak and after-peak time interval, for outbound traffic, varied between both times. The variance was only very low though and is summarised in Table 73.

Table 73 Comparison of Results Between Detour 1 and 2, in inter-peak and after-peak periods

Direction	Time Interval	Detour Number	Degree of Saturation
Outbound	Inter-peak	1	1.481
Outbound	Inter-peak	2	1.130
Outbound	After-peak	1	1.237
Outbound	After-peak	2	1.287

Based on the output, it was suggested that private vehicles utilise detour number 2 when travelling outbound in the inter-peak, and detour number 1 when travelling outbound in the after-peak. As can be seen though, the difference in the degree of saturation between detour number 1 and 2 for the after-peak period is almost negligible. Therefore, for ease of use for public transport patrons, for busses only, detour 2 will be utilised for both inter-peak and after-peak periods. This should assist in ensuring the services remain easy to use and confusion between patrons regarding which stop to use, during which time period, is minimised.

7.3.3.1. Outbound: Existing and Temporary Stop

Similar to the above, the most appropriate route for busses to take in the outbound, inter-peak period has been classed as route 2. This route takes bus services from the CBD down Dequetteville Terrace, Rundle Street, The Parade West and Fullarton Road.

Figure 177 shows the location of existing stops (blue) and temporary stops (red) to be used during the construction period. These include one additional stop on Dequettivelle Terrace, The Parade West, and one on Fullarton Road.

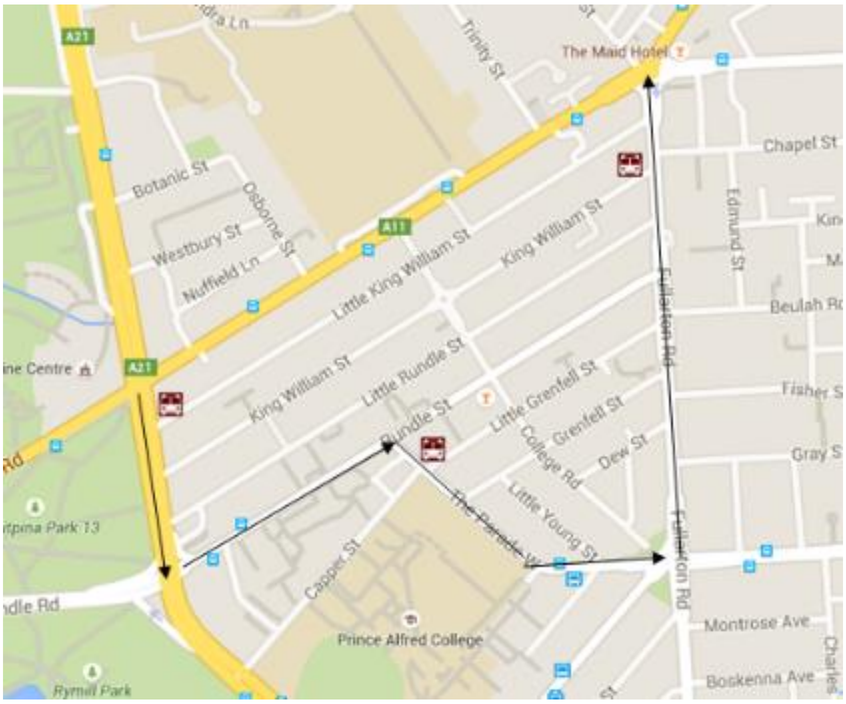

Figure 177 Outbound Detour, Existing and Temporary Stops

7.3.4. Signage

During the construction, the appropriate signage will be displayed to inform and control bus users. The signage must inform passengers and drivers on existing bus stop changes, service time alterations, speed limits, no left/right turn and no entry/exit warnings. A template of the signs which will be posted on local bus stops to inform residents of the changes is shown in Appendix, Section 4.3.

It is also vital that Adelaide Metro are aware of the construction works, and its impacts, and can provide passengers with accurate information of closed and temporary stops.

7.4. Traffic Management Plans

Following this, traffic management plans were developed. The first step in completing this process involved liaising with other teams to understand what construction work is required, where the construction work is located, the duration of each task and the machinery required. By completing this, the transport team could ensure that appropriate traffic management plans were developed.

The output of this process is shown in Table 74 below.

Table 74 Schedule of Works which Require Traffic Management

Work Required	Location and Dimensions of Work	Estimation of Duration of Works	Appropriate Traffic Management
Conventional Stormwater Installation			
Dig trench, excavation and removal of material	Southern side of road, 720m length, 4m from edge of kerb	1.2 months	Closure of 2 lanes inbound
Installation and connection of pipe	Same as above	1.2 months	Closure of 2 lanes inbound
Resealing of road surface	Same as above	3 weeks	Closure of 2 lanes inbound
Dig trench for connection to mains system and repair pavement	4 connections along a 14m length of road. Each connection runs perpendicular to the direction of traffic.	2 nights for each of the 4 connections (1 night to install connection, 1 night to reseal road)	Full road closure with detours implemented
Installation of Bio-retention System			
Remove surface soil for installation of bioretention basin and construction of system	Green area outside Royal Park Hotel carpark, 40m along the pavement and 2m wide	2 months	Closure of 2 lanes inbound
Implementation of second bioretention basin	Outside school carpark	2 months	Closure of 2 lanes outbound

Installation of Environmental Controls			
Installation of gross pollutant trap	Directly connected to culvert	3 days	Closure of 2 lanes inbound
Construction of Structural Components			
Placing concrete and allowance for curing	At culvert	10 days	Closure of 1 lane inbound

Further to this, other traffic management plans were developed. The extra traffic management plans were developed for use if traffic management requirements or timing of works changes, during construction of the project. This ensures all construction work can be completed using the traffic management plans which have already been developed by Hydro Future.

The other plans produced included:

- 1 lane closed outbound
- 2 lanes closed (1 on each side)

A traffic management plan was also developed for each detour which had been predefined in this report as feasible. Four detour traffic management plans were produced, for inbound and outbound, inter-peak and after-peak time frames. Pedestrian detour examples were also provided.

It should be noted that whilst viewing these traffic management plans, the orientation of the signs are rotated to be in line with the direction of travel of the vehicle. This is intended to show the perspective that the driver will see whilst viewing the traffic signs.

7.4.1. Development of Traffic Management Plans

The traffic management plans defined above were then developed. To develop the relevant traffic management plans the team used the Department of Planning, Transport and Infrastructure (DPTI) Field Guide-Traffic Control Devices for Workzone Traffic Management manual (DPTI, 2012) and the SA Standards for Workzone Traffic Management (DPTI, 2012), also produced by the DPTI.

7.4.1.1. Use of 25kmph Speed Limit

The description section of the DPTI's Traffic Control Devices for Workzone Traffic Management Field Guide (DPTI, 2012), specifies that a 25kmph speed zone may be used if the work area is classed as hazardous.

For a work zone to be considered hazardous the workers must be either:

- Working on a carriageway which contains minimal line marking or separation (e.g. a median) between the worker and passing vehicles
- Working less than 1.5m from live traffic with minimal use of machinery (i.e. majority of work is completed on foot-workers are not protected by machinery cabin) or
- Working in a construction area where the location of the workzone causes the surroundings to become hazardous.

In this case, each workzone was considered hazardous due to the minimal distance which will exist between workers and live traffic, and also due to the lack of line marking and medians in the midblock of the carriageway. Therefore, the implementation of a 25kmph speed zone is acceptable in the workzones which would be setup to construct this design.

7.4.2. Traffic Management Plans –Lane Closures

The traffic management plans that were developed for lane closures are shown below, in Sections 7.4.2.1 to 7.4.2.4.

7.4.2.1. One Lane Closed Inbound (Southern Side)

For the single lane closure of North Terrace, Kent Town, it was determined that the workzone length at any one point should be a maximum of 150-200m. Limiting the workzone to this length allows a smaller Advanced Warning (AW) Area, Taper Area (TA) and Safety Buffer (SB) and therefore maximises efficiency in the workplace and allows traffic to easily merge after passing through the bordering intersections, or disperse on approach to an intersection. If a larger work area is required, then plans similar to those shown in Section 7.4.3.2 are required to be setup, which provide drivers with advance notice of the works, prior to entering the bordering intersections. The details of the road closure can be seen below in Table 75, and were derived from the Figure, Table and Notes in Section 2.1.1.1 of the DPTI Field Guide (DPTI, 2012).

The current works which are scheduled to be completed during this lane closure, are the structural works which include placement of the concrete at the culvert. This work zone will be setup for 10 days to allow the concrete to be placed and cured. When this setup is implemented, it will be the same as that shown in the following figure, but the length of the work area will be reduced. All other zone lengths will remain the same, as these are only dependent on the speed of the road and type of workzone setup.

Table 75 Workzone-Defined Lengths for One Lane Closed Inbound

Area of Work Zone	Length of Zone (m)	Spacing of Cones within Zone (m)
Buffer Zone (BZ)	Not required	Not required
Advance Warning (AW) Area	45	Not required
Taper Area (TA)	60	9
Safety Buffer (SB)	20-30	18
Work Area (WA)	180	18
Termination Area (ML)	15 (optional)	18
Minimum Residual Lane Width	3	NA
Minimum Clearance from Traffic to Cones or Bollards	0.5	NA

Figure 178, shows the layout of the works to occur along North Terrace. This is a single lane road closure which will restrict movement into the city. It is recommended that this is implemented in the inter-peak or PM peak period, to reduce delay to peak traffic flow.

A larger copy of Figure 23 can be found with the attached drawings, see drawing number HF-302.

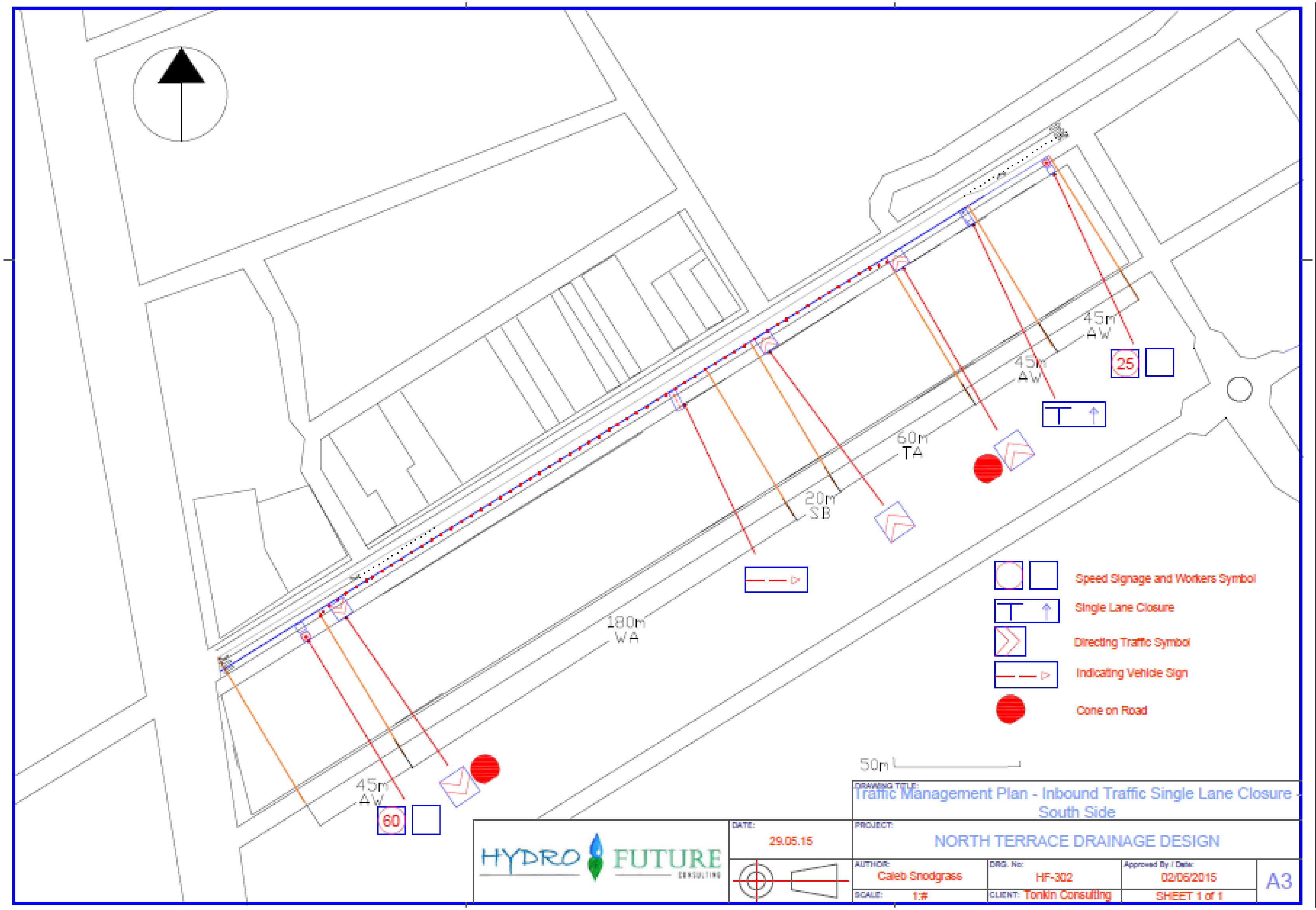

Figure 178 CAD Representation of Workzone Setup-One Lane Closed Inbound

Figure 179, below, shows greater details of the above CAD drawing and how the work zone traffic management system will be implemented. The CAD drawing also shows the lengths and dimensions of each area to scale. For example, it shows the Advanced Warning Area (AW) as 45m and also shows where the signs shall be placed for optimum and safe traffic movement.

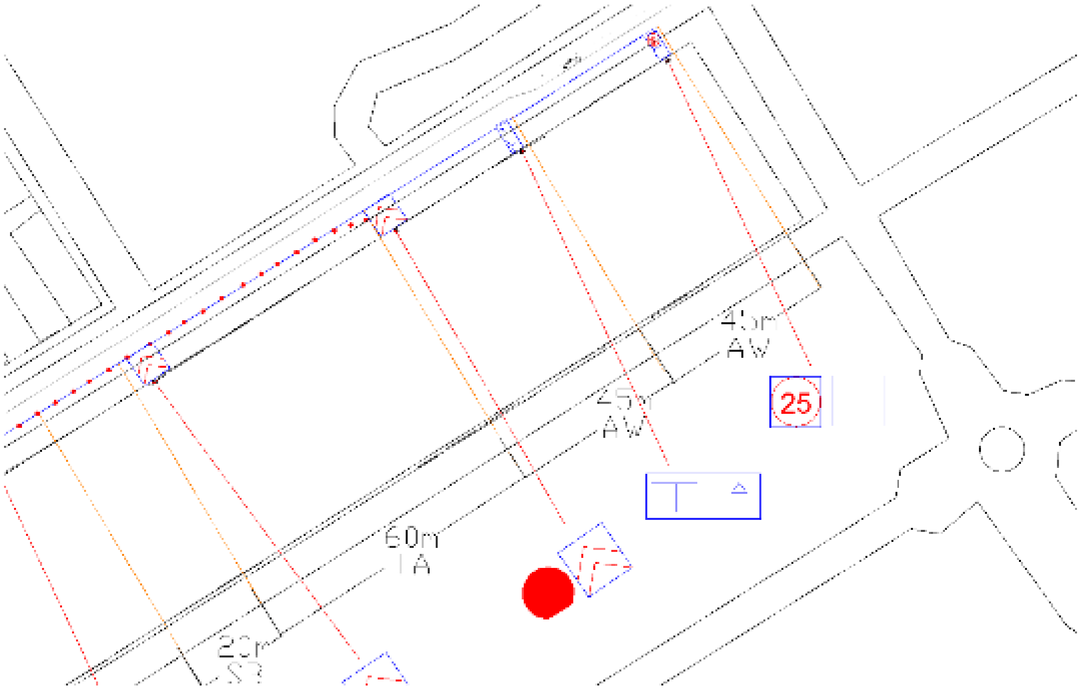

Figure 179 One Lane Closed Inbound CAD Detail

7.4.2.2. Two Lanes Closed Inbound (Southern Side)

These two lanes are required to be closed outside the car park of the Royal Hotel for three primary construction aspects. These include the construction and installation of the:

- Bioretention System
- Gross Pollutant Trap
- Conventional Stormwater System

Though the works for the bioretention system, involve the use of the green area which is on the far side of the pavement from the road, it is still a requirement that two lanes are closed during construction. The reason for this, is that a backhoe loader 3CX will be used, which has a width of 2.4m. As the width of the pavement is 2.6m, it is recommended that this machinery is placed in the far left hand lane during construction.

When using this backhoe loader, a travel clearance of 3.61m is also required, and to satisfy this, requires the closure of two lanes on the inbound side, outside the Royal Hotel car park.

This same setup would be used when the trench is dug, and pipe is placed for the conventional stormwater system. This construction aspect would also require the closure of 2 lanes due to the size of the machinery. It should be noted that the estimate length of this work area is 720m, though the construction will be completed in stages, digging the trench, placing and connecting the pipe and then resealing the pavement before moving on to the next stage. This means that any one time, the work area length will be considerably shorter than 720m. The length of the work area is arbitrary, and will depend on pipe lengths. This will not change the setup shown in this section, as the length of the AW, TA, and SB are only dependent on the speed of the road and type of setup. Therefore, this setup will be used for the installation of the conventional stormwater system, but the length of the work area may vary.

This setup will also be used for the installation of the GPT. The GPT will be located at the same location as the culvert, and installation of this requires 2 lanes to be closed inbound.

Again, it is recommended that this is setup during the inter-peak or PM peak time period.

Based on the speed of the road being 60kmph, the following information was acquired, using the Tables and Notes Section of Figure 2.1.1.1 (DPTI, 2012):

Table 76 Workzone-Defined Lengths for Two Lanes Closed Inbound

Area of Work Zone	Length of Zone (m)	Spacing of Cones within Zone (m)
Buffer Zone (BZ)	Not required	Not required
Advance Warning (AW) Area	45	Not required
Taper Area (TA)	60	9
Safety Buffer (SB)	20-30	18
Work Area (WA)	40	18
Termination Area (ML)	15	18
Minimum Residual Lane Width	3	NA
Minimum Clearance from Traffic to Cones or Bollards	0.5	NA

Using the information in Table 76, this work zone would be setup as shown in Figure 180

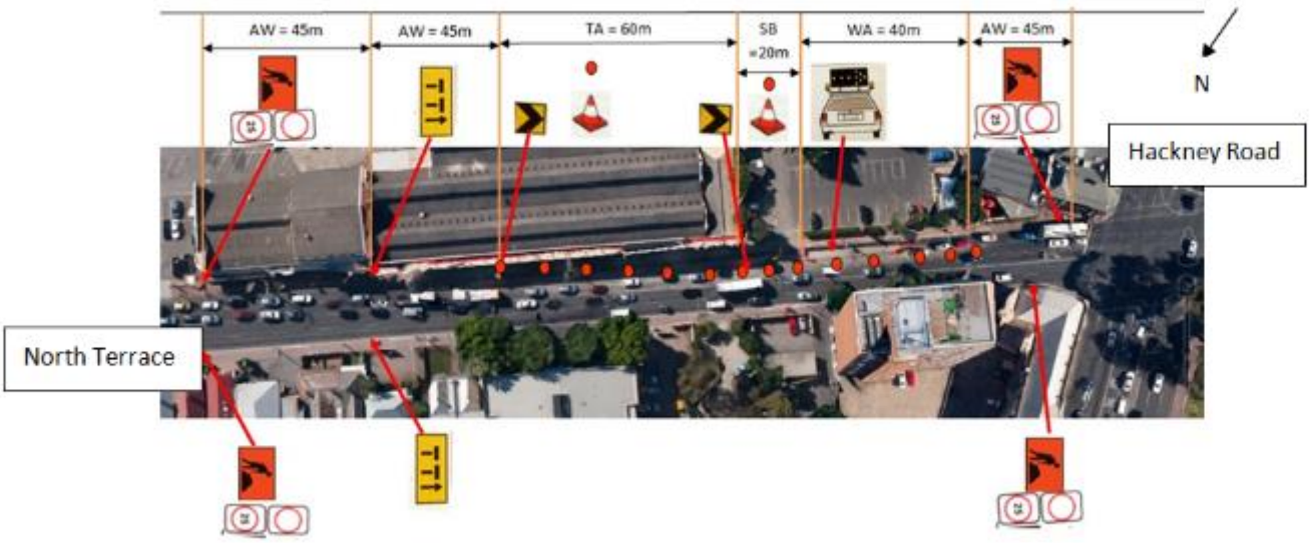

Figure 180 Workzone Setup-Two Lanes Closed Inbound

The first sign which the driver encounters, requests that the vehicle's speed is slowed to 25kmph. Though blank on this image, the reverse of this sign is called a Return to Road Speed Limit Sign, this lets drivers travelling in the opposite direction know that the construction zone is cleared, and in this case, they can return travelling at 60kmph.

The next sign warns drivers that in the near distance, the road merges to 1 lane.

After the work zone the road then returns to normal conditions and speed, which is indicated by the Return to Road Speed Sign. As specified in the Traffic Control Devices for Workzone Traffic Management Field Guide (DPTI, 2012), in this case the termination area is optional. The termination area was not setup in this plan due to the close proximity of the works to the intersection. This ensures the traffic has sufficient space to manoeuvre back into the appropriate lane, to perform movements at the intersection

7.4.2.3. One Lane Closed Outbound (Northern Side)

A traffic management plan for the closure of one outbound lane was then developed, with zones defined in Table 77. The lengths of these were determined using Figure, Tables and Notes from Section 2.1.1.1 of the DPTI Field Guide (DPTI, 2012)

Table 77 Workzone-Defined Lengths for One Lane Closed Outbound

Area of Work Zone	Length of Zone (m)	Spacing of Cones within Zone (m)
Buffer Zone (BZ)	Not required	Not required
Advance Warning (AW) Area	45	Not required
Taper Area (TA)	60	9
Safety Buffer (SB)	20-30	18
Work Area (WA)	40	18
Termination Area (ML)	15	18
Minimum Residual Lane Width	3	NA
Minimum Clearance from Traffic to Cones or Bollards	0.5	NA

The setup begins at the corner of Hackney Road and North terrace with an advanced warning (AW) space of 45m. Within the advanced warning area there are signs which communicate to drivers, the upcoming presence of roadwork and a change of speed limit to 25kmph.

Following this, there is another 45m AW relaying closure of the left lane.

The TA then has a length of 60m with cone spacing of 9m tapering cones until the left lane is closed.

Afterwards, on the left hand side, is Nuffield Lane which has been blocked with a no left turn sign and the location of workers and construction in the work area (WA). This setup is shown in Figure 181.

Figure 181Workzone Setup-One Lane Closed Outbound

Figure 182 is a continuation of this zone showing the cones with the lane closure and a 45m AW with an “END ROADWORK” sign.

Figure 182 Workzone Setup-One Lane Closed Outbound -End of Works

Currently, there is no work scheduled to be completed during this closure, meaning the length of the work area is arbitrary, and can be changed to suit construction requirements.

This was also represented using AutoCAD as seen in drawing HF-303.

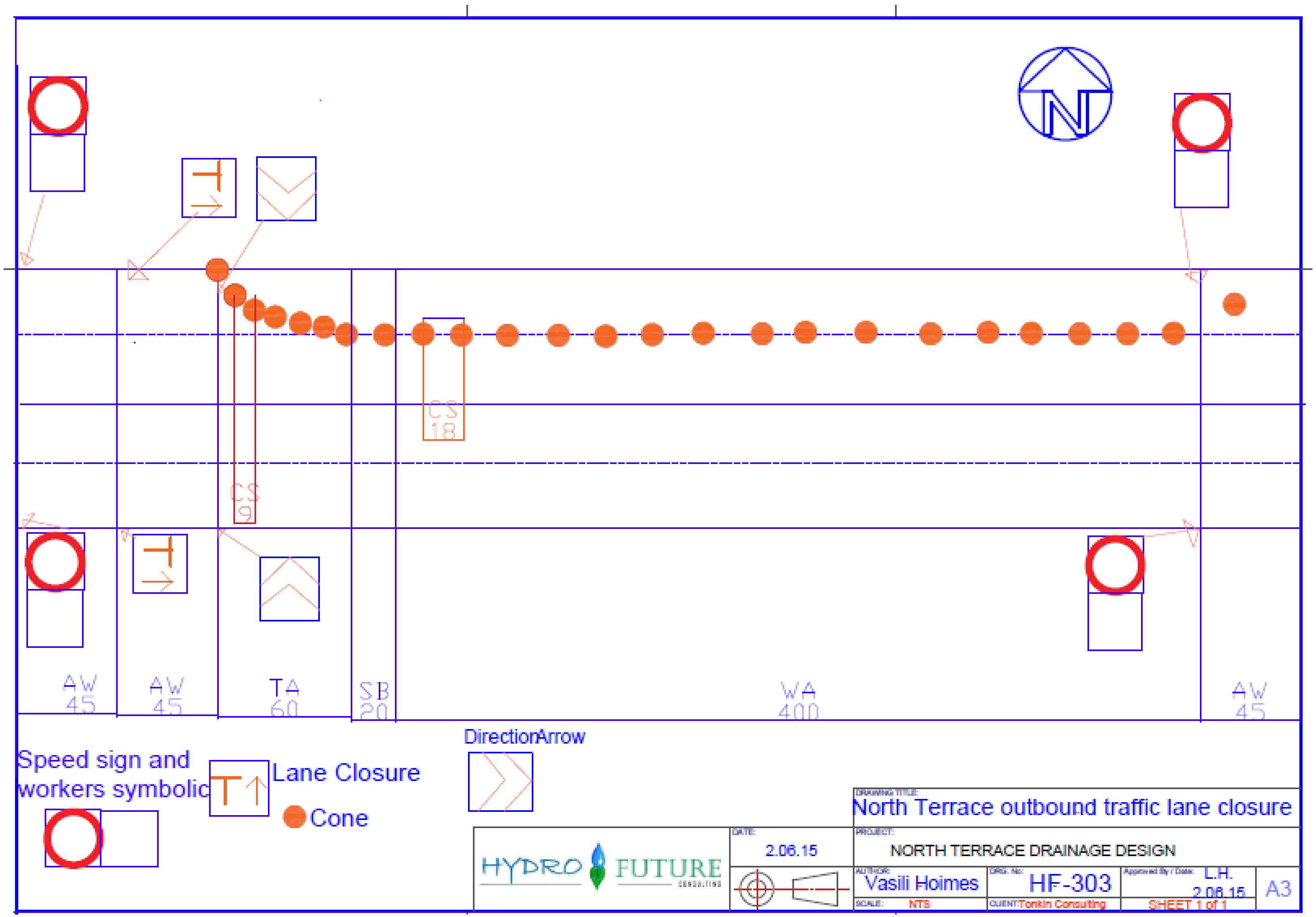

Figure 183 Workzone Setup-One Lane Closed Outbound-CAD Representation

7.4.2.4. Two Lanes Closed (One Lane Closed on Each Side)

A traffic management plan was also developed for two lanes to be closed, one on each side of the road. It should be noted that currently, there are no works which are scheduled that require the use of this detour, meaning that the length of the work area (WA) is arbitrary and may change if this plan was implemented during construction.

The lengths of the defined zones are as shown in Table 78 and were derived using Tables, Notes and Figures from the DPTI Field Guide Section 2.1.1.1 (DPTI, 2012_.

Table 78Workzone-Defined Lengths For Two Lanes Closed, One Each Side

Area of Work Zone	Length of Zone (m)	Spacing of Cones within Zone (m)
Buffer Zone (BZ)	Not required	Not required
Advance Warning (AW) Area	45	Not required
Taper Area (TA)	60	9
Safety Buffer (SB)	20-30	18
Work Area (WA)	50 (subject to change depending on extent of works)	18
Termination Area (ML)	15 (optional)	18
Minimum Residual Lane Width	3	NA
Minimum Clearance from Traffic to Cones or Bollards	0.5	NA

The workzone would then be setup as shown in Figure 184

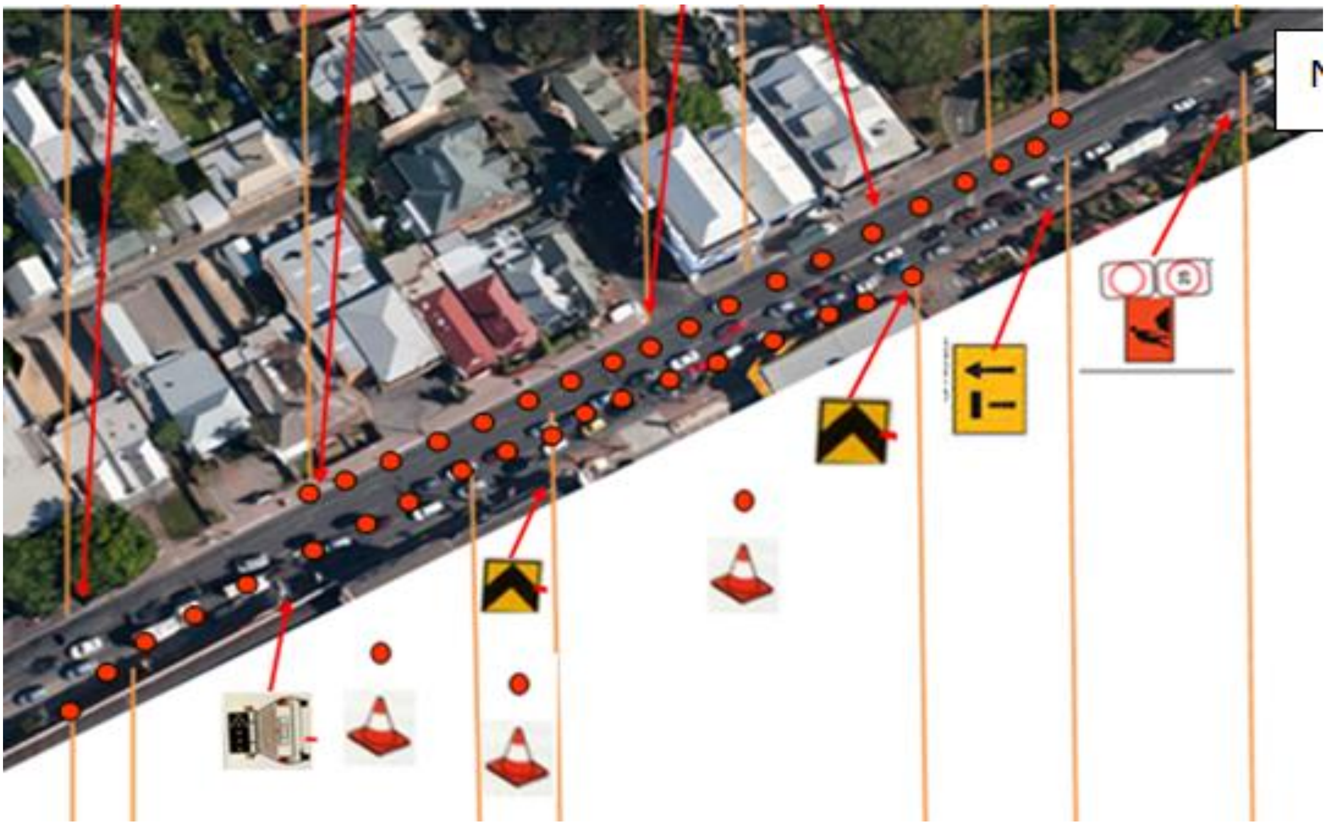

Figure 184 Workzone Setup-Two Lanes Closed, One Each Side

This setup can also be represented using the AutoCAD software as seen in Figure 185.

A larger version of the CAD representation can be found in the drawings section of this report. Please see drawing HF-304.

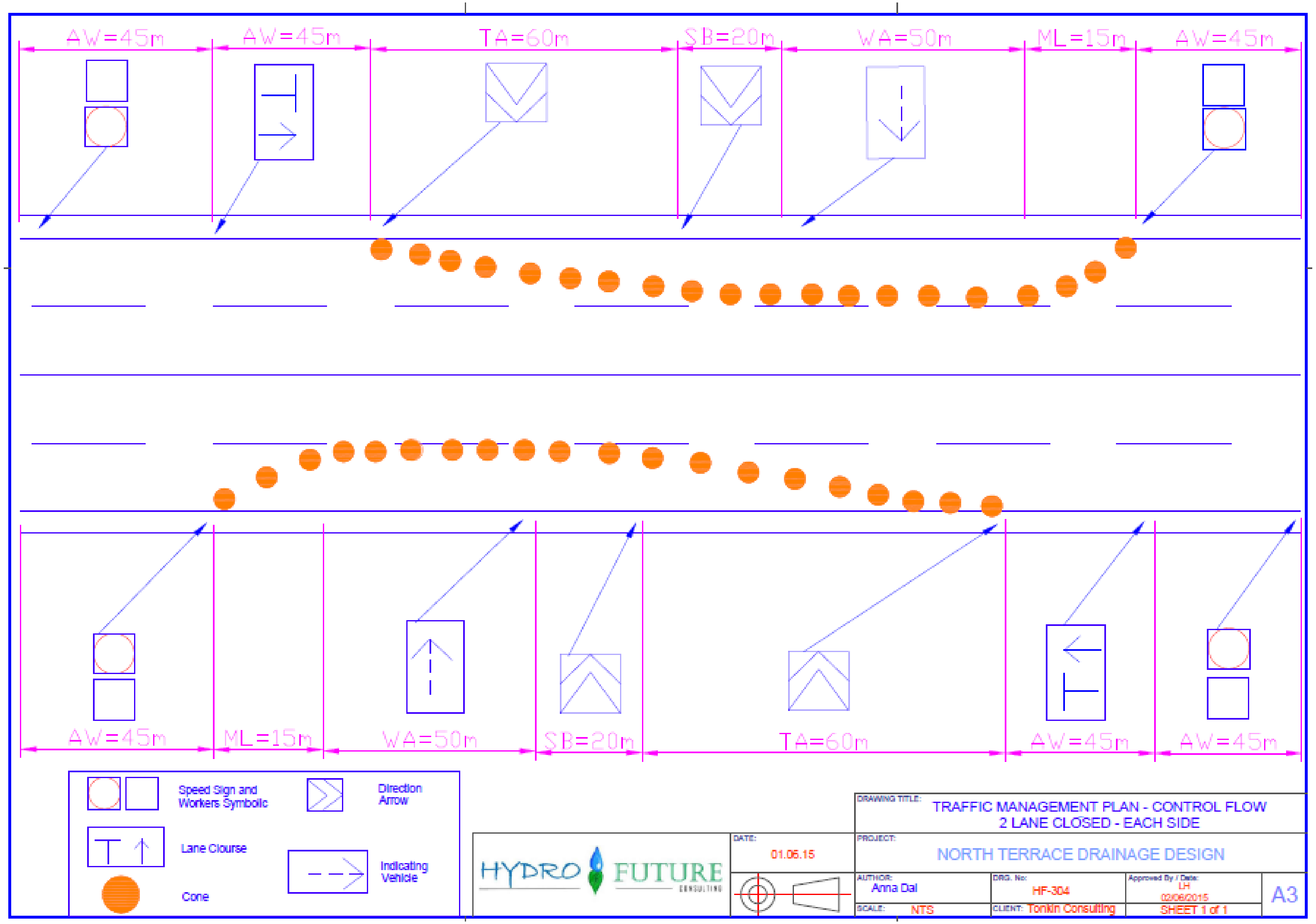

Figure 185 Workzone Setup-Two Lanes Closed, One Each Side CAD Representation

7.4.3. Traffic Management Plans – Lane Closures with Contra Flow Traffic

Traffic management plans were then developed which considered the use of contra flow on both sides of the carriageway. Contra flow conditions are setup when one entire side of the road is closed, and vehicles travel in both directions on the open side of the road.

It should be noted that the implementation of any contra flow traffic management plan, should be implemented in the inter-peak period.

7.4.3.1. Two Lanes Closed Outbound (Northern Side), Contra Flow Inbound

The next traffic management plan which was developed involved closing both lanes in the outbound direction, and implementing a contra flow setup on the inbound side of the carriageway. This traffic management plan could be implemented if the construction of the second bioretention system, which is located at the front of the local school, went ahead. As discussed in Water section 4.5.6 though, this is optional and implementation of this plan may not be required.

On the below map (Figure 186) the work zone which this traffic management plan was developed for is highlighted in yellow.

Figure 186 Highlighted Construction Zone-Bioretention System 2

Again, the speed of this road is 60kmph, and based on this the following zones were defined in Table 79. This information was based on the information in the DPTI's Traffic Control Devices for Workzone Traffic Management Field Guide, Figure and Tables and Notes for 2.1.1.3 (DPTI, 2012) for multi-lane roads, midblock, undivided carriageway where a short term merge and lateral shift taper are required.

Table 79 Workzone-Defined Lengths for Two Lanes Closed Outbound

Area of Work Zone	Length of Zone (m)	Spacing of Cones within Zone (m)
Buffer Zone (BZ)	Not required	Not required
Advance Warning (AW) Area	45	Not required
Taper Area (TA)	60	9
Safety Buffer (SB)	20-30	18
Work Area (WA)	120	18 and 12 on centreline
Termination Area (ML)	15	18
Minimum Residual Lane Width	3	NA
Minimum Clearance from Traffic to Cones or Bollards	0.5	NA

The workzone setup was then determined and represented using AutoCad, as seen in Figure 187.

A larger copy of this drawing can also be found in the drawings section of the report, see drawing HF-301.

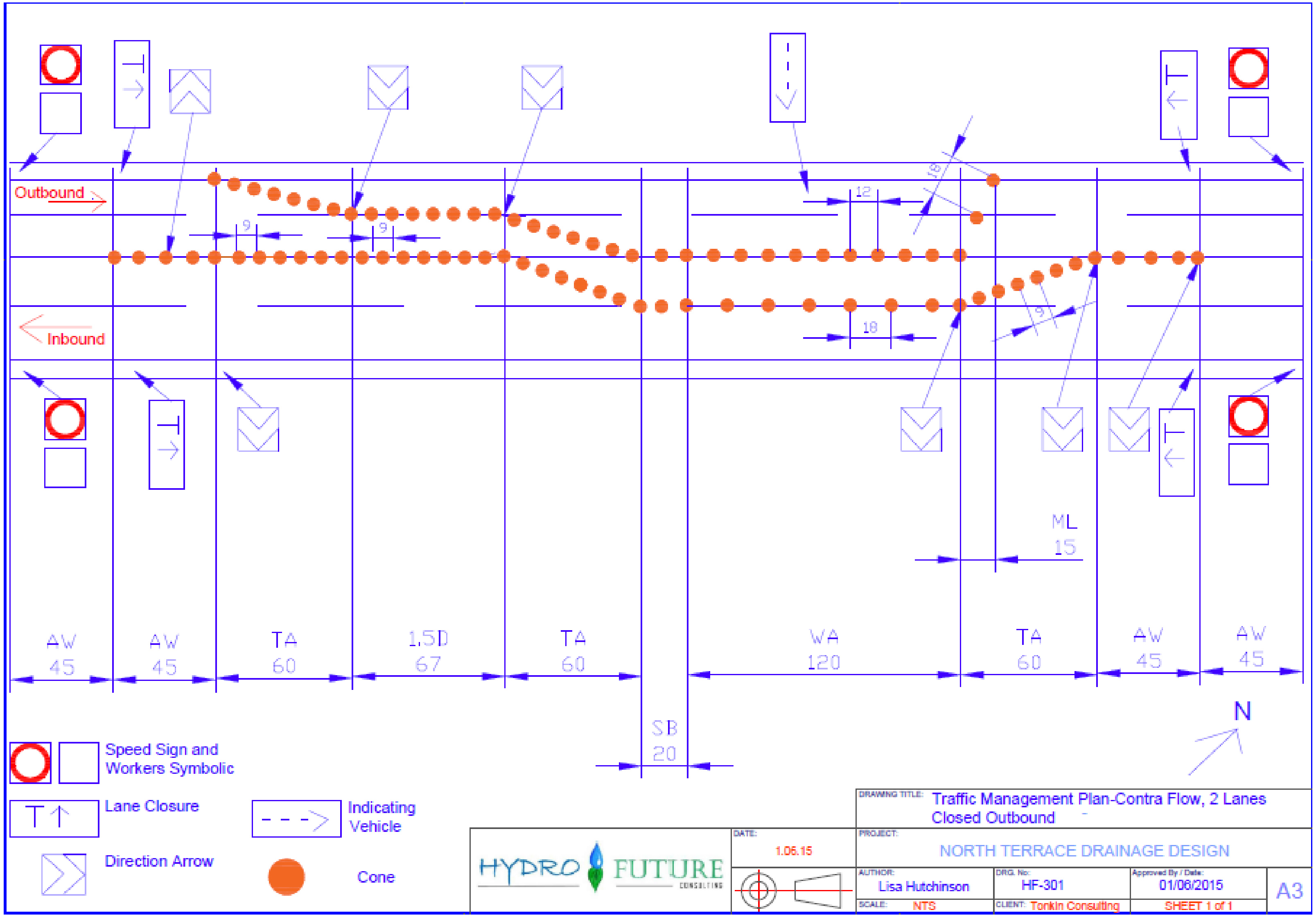

Figure 187 Workzone Setup-Two Lanes Closed Outbound CAD Representation

As described in Section 7.4.2.1, Return to Road Speed Limit Signs are used along with cones, lane closure signs, directional arrows and indicating vehicles to setup this workzone. This has been drawn so that inbound traffic is flowing to the left, and outbound is to the right.

7.4.3.2. Two Lanes Closed Inbound, Entire Length of Road, Contra Flow Outbound

A traffic management plan which closes the entire side of the inbound carriageway was also developed, with traffic flowing in contra flow conditions on the outbound carriageway. This traffic management plan would primarily be used for the installation of the conventional stormwater system which runs parallel to the direction of traffic. This plan would be required, when the length of the work area, exceeds the length of the slip lane at the North Terrace/Hackney Road intersection, reducing the number of lanes to two lanes in each direction.

As mentioned, though this has been shown setup with a work area of 720m, the construction will happen in stages, meaning the work area is likely to be shorter than that defined in this example.

The relevant work zone dimensions were determined using the notes and tables for Figure 2.1.1.4 of the DPTI's Workzone Traffic Management Field Guide (DPTI, 2012) and presented in Table 80. This setup is used for a multilane undivided road, which is a midblock section that requires a merge and lateral shift taper as a long term setup. The long term traffic management plan was used, as this step of construction was assumed to require a significant amount of time.

Table 80 Workzone-Defined Lengths for Two Lanes Closed Inbound, Entire Road Length

Area of Work Zone	Length of Zone (m)	Spacing of Cones within Zone (m)
Buffer Zone (BZ)	Not required	Not required
Advance Warning (AW) Area	45	Not required
Taper Area (TA)	60	9
Safety Buffer (SB)	20-30	18
Work Area (WA)	720	18 and 12 on the centreline
Termination Area (ML)	15	18
Minimum Residual Lane Width	3	NA
Minimum Clearance from Traffic to Cones or Bollards	0.5	NA

To minimise the impact on traffic, it is suggested that this work is completed during the inter-peak time frame due to the capacity of the intersection of North Terrace, Fullarton Road, Magill Road and

Payneham Road, due to multiple lane closures being required at this intersection. Multiple lanes will be closed at the intersection because the length of the work area in this example is 720m, and the entire length of midblock is 770m. This does not allow sufficient warning for drivers if the setup was implemented after the intersection, and hence, advanced notice is provided before the intersection, requiring the closure of lanes.

Unlike other traffic management plans developed as part of this detailed design, the first image (Figure 188) shows how the workzone will be setup in the construction area and the following images, show the setup which is required on the arterial roads, on the approach to the construction area.

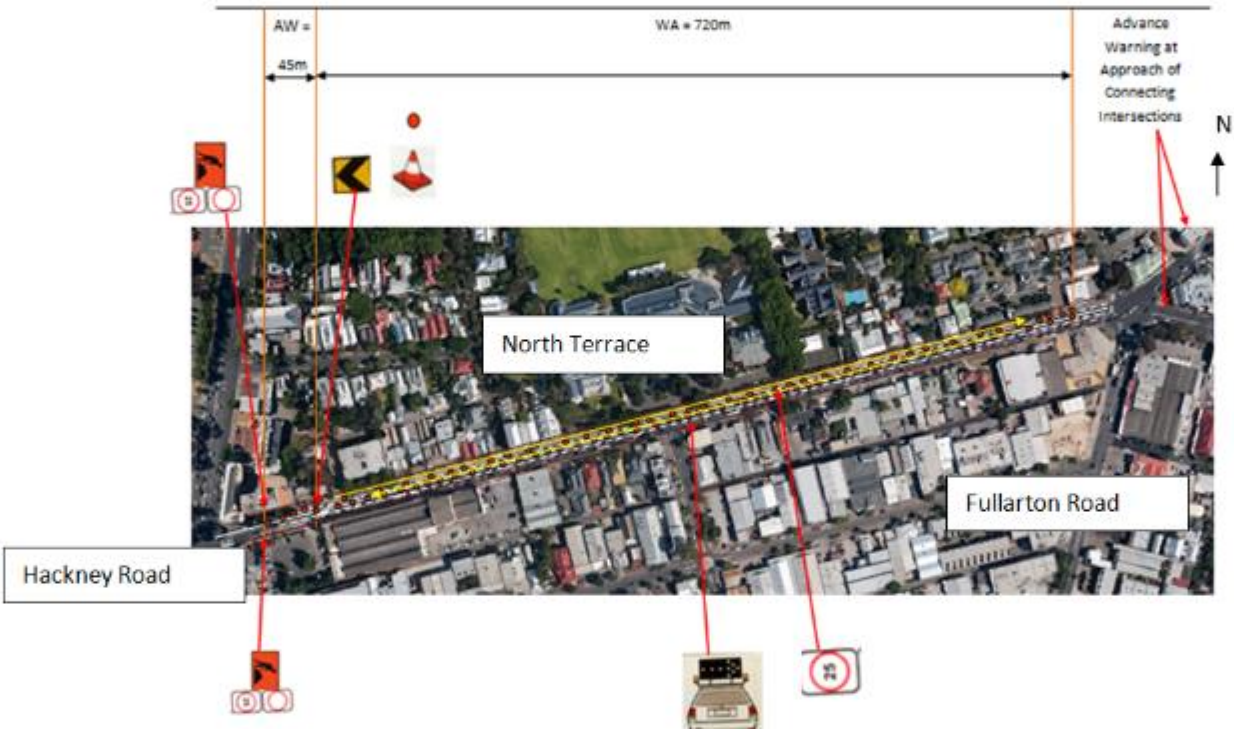

Figure 188 Workzone Setup-Two Lanes Closed Inbound, Entire Road LEngth, Work Area

In Figure 188, the yellow lines on the road represent the traffic flow, which has both inbound and outbound traffic flowing on the outbound carriageway. This is similar to the setup shown below in Figure 189.

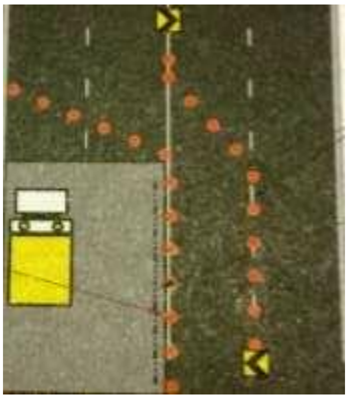

Figure 189 Example of Two Lane Closure Contra Flow

This traffic management plan also utilises repeater signs, which remind road users of the speed limit which is required within the construction zone. These are implemented as part of this plan due to the extensive length of the work area.

The below image (Figure 190) displays the work zone that would be setup at the Fullarton Road approach. The yellow box represents the construction area. It should also be noted that whilst this traffic management plan is implemented, left hand turns from King William Street will be permitted, but right hand turns onto King William will be banned, as this will cause congestion and large queue lengths that will impact the intersection efficiency.

Figure 190 Workzone Setup-Two Lanes Closed Inbound-Fullarton Road Approach

Similar to the above image, Figure 191 shows the setup of the workzone on Magill and Payneham Road. The tapers on Magill Road are sharper than those on Payneham road due to the median which exists leading up to the intersection.

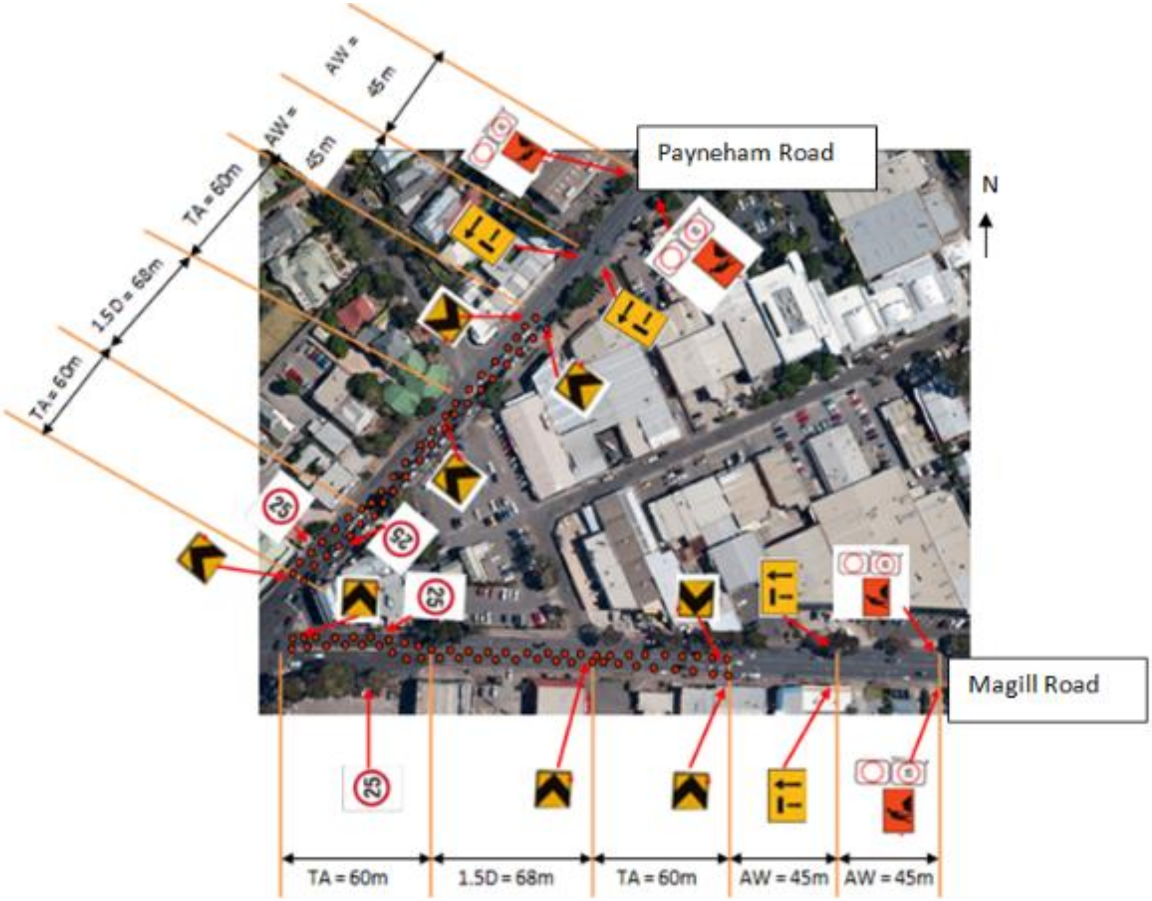

Figure 191 Workzone Setup-Two Lanes Closed Inbound-Magill Road and Paynheham Road Approach

7.4.4. Traffic Management Plans – Detours

Traffic management plans were also developed for each of the detours considered as part of this design. This includes detours for both the inter-peak and after-peak time intervals and inbound and outbound direction.

It should again be noted that currently, it is proposed that full closures with detours are only used during the after-peak period. The after-peak closures, and detours, will be setup so that connection to the mains pipe and resurfacing of the asphalt can be completed. It had been confirmed previously in this report that these tasks would be completed as night works, as the connections run perpendicular to the direction of traffic and a full closure is not appropriate during other time periods.

7.4.4.1. Inter-Peak, Inbound

Figure 192 shows the detour which will be setup to allow vehicles to bypass the entire road works area, but still allows them access to the city with minimal increase in delay time. The detour bypasses North Terrace and directs vehicles down Fullarton Road to Flinders Street and then back to Dequetteville Terrace.

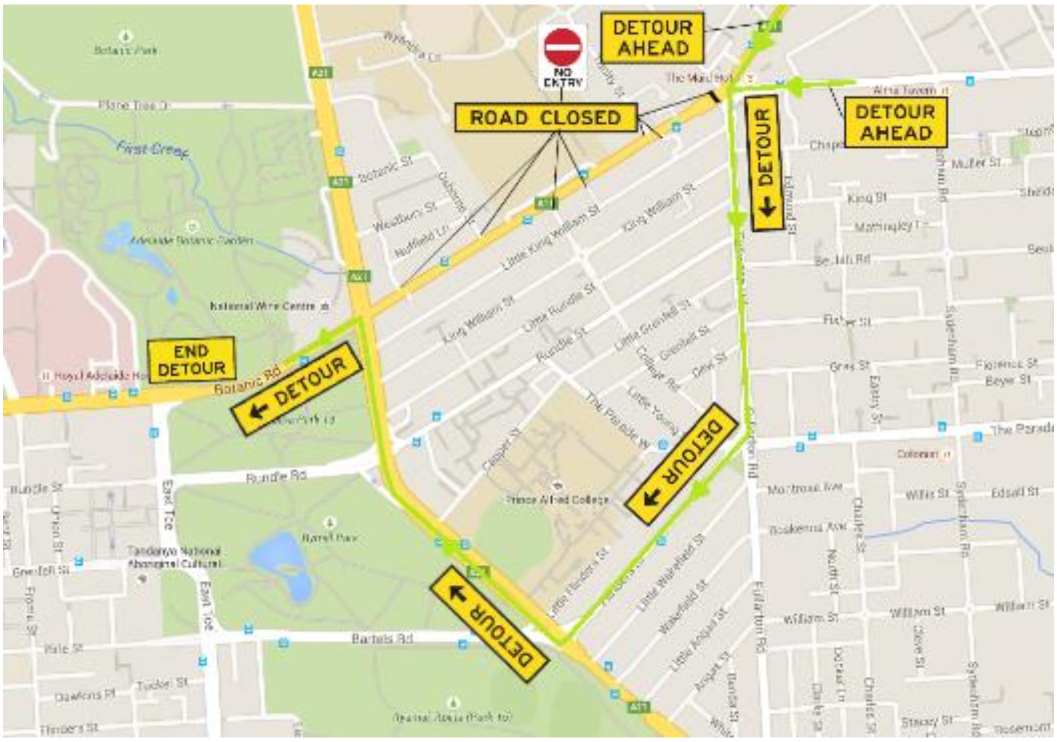

Figure 192 Inter-peak, Inbound Detour

The detour signs have been setup to ensure the detour route is clear for drivers accessing this. Road closure signs have also been placed to ensure people attempting to access North Terrace from the connecting streets, are aware that they must utilise the detour.

7.4.4.2. Inter-Peak, Outbound

The outbound, inter-peak, detour encourages drivers to use the route highlighted below. In Figure 193 the red area represents the closed road for construction, and the yellow arrows outline the detour route.

Figure 193 Inter-peak, Outbound Detour-Detour and Construction Zone

Detour signs are then setup as shown in Figure 195 to Figure 198.

Figure 194 shows the signage required at the intersection of Hackney Road and North Terrace. The signage effectively informs road users that the road ahead is blocked, and also highlights the turns which are not permitted from Hackney Road, onto North Terrace.

Figure 194 Inter-peak, Outbound Detour-Hackney Road/North Terrace

Vehicles are then redirected down Rundle Street, which is communicated to vehicle users through the detour marker.

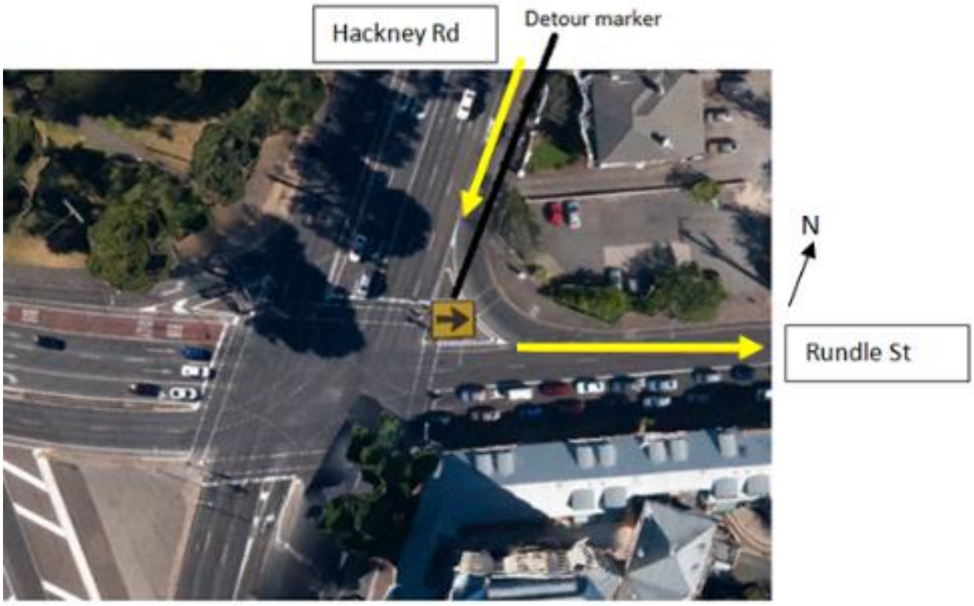

Figure 195 Inter-peak, Outbound Detour-Hackney Road/Rundle Street

The efficiency of this detour also relies on the use of a temporary signal system at the intersection of Rundle Street and the Parade. On approach to the temporary signals, a “prepare to stop” and signalling sign are erected to notify drivers of the changed traffic conditions ahead. An advance warning area of 45m is then setup, and the signals are placed 6m away from this.

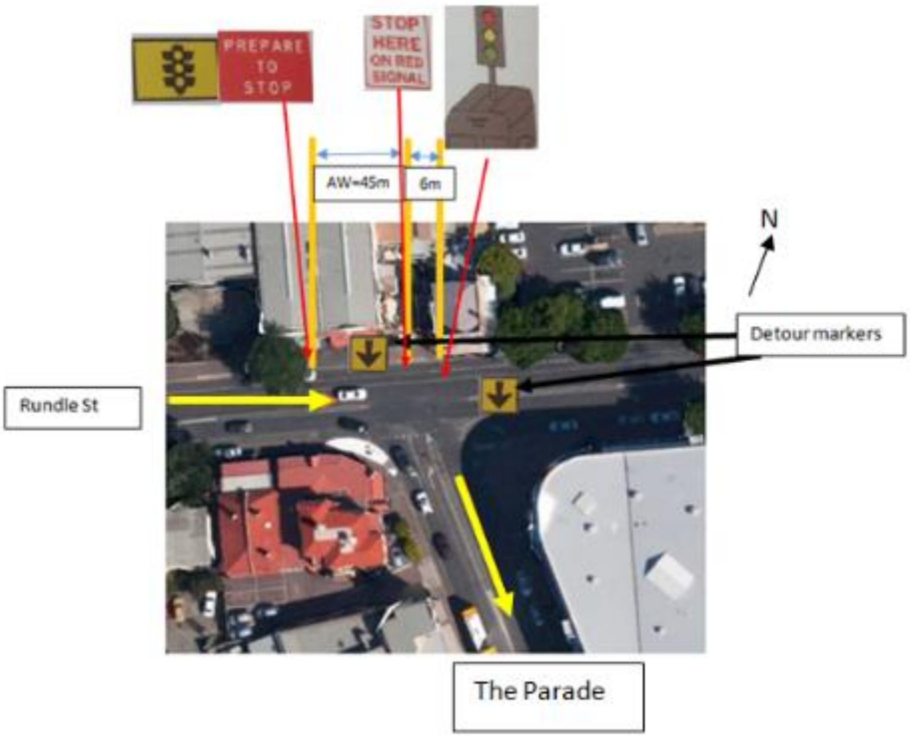

Figure 196 Interpeak, Outbound Detour-The Parade, Rundle Street

After travelling along The Parade, vehicles are then redirected along Fullarton Road, and this is shown again through the use of detour markers.

Figure 197 Inter-peak, Outbound Detour - The Parade/Fullarton Road

The end of the detour is then highlighted in Figure 198. Road closure signs will also be placed further up Payneham and Magill Road to give drivers early notice of the upcoming closure.

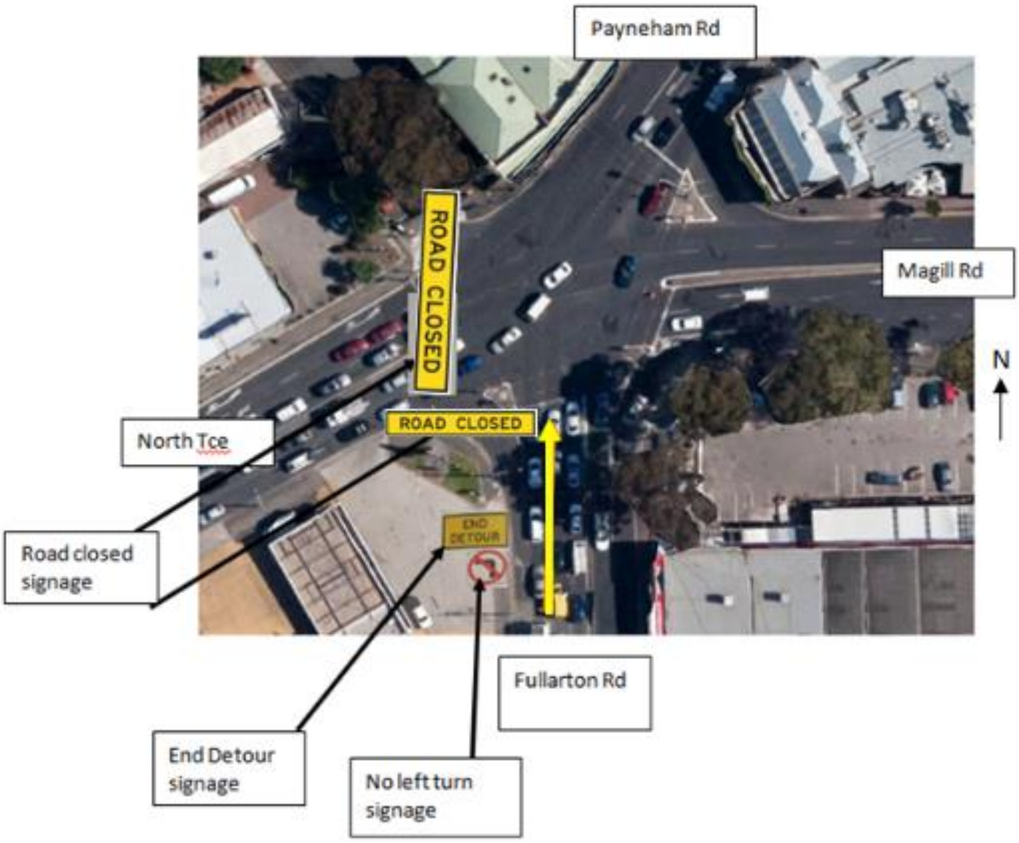

Figure 198 Inter-peak, Outbound Detour, Fullarton Road/Magill Road

7.4.4.3. After-Peak, Inbound

Traffic management plans were also developed for the after-peak, inbound traffic as shown in Figure 199. In this figure, the yellow box shows the closed construction zone and yellow arrows show the detour route.

As can be seen, the use of temporary barriers are implemented in this plan, along with no entry signs to ensure private vehicles do not enter the workzone. A temporary speed limit of 40kmph is also implemented directly around the beginning of the detour. This is not required, but is considered safe practice, as during night hours (the after-peak time interval), drivers unfamiliar with the area may be confused about the detour and where they are expected to drive.

Figure 199 After-peak, Inbound Detour

7.4.4.4. After-Peak, Outbound

A similar setup is shown (Figure 200) for the after-peak time interval in the outbound direction. Again, the construction zone is highlighted in a yellow box and yellow arrows indicate the proposed detour route.

The use of a 40kmph temporary speed zone was also implemented in this detour and signs were placed to ensure the detour route is clear for drivers.

Figure 200 After-peak, Outbound Detour

As can be seen in the above image, the after-peak, outbound, detour requires the use of temporary signals at the intersection of Rundle Road and Fullarton Road. Road users are given advance warning of the changed traffic conditions, prior to the intersection through prepare to stop and traffic signal signs. Stop here on red signal signs are also used to indicate to road users the appropriate stopping line for these signals.

7.4.5. Traffic Management Plans – Pedestrian Detours

During full road closures, it is a requirement that pedestrians have full access to businesses and residential estates within the construction zone. This is discussed in detail in Section 7.2, but specific traffic management plans are shown below in Sections 7.4.5.1 and 7.4.5.2.

It should be noted that for each pedestrian detour, temporary fencing will be placed as a barrier between the footpath, and the construction zone. This would be placed for the full length of the work area.

7.4.5.1. Royal Hotel Pedestrian Access

It has been recommended that the full closures with detours are implemented in the after-peak period. Section 7.2.6 highlighted that there are many allotments along this part of North Terrace which are unlikely to be accessed during after-peak hours, but the Royal Hotel has opening hours which suggest pedestrians will require access to this location in this time interval.

The pedestrian detour for access to the hotel is shown in Figure 201.

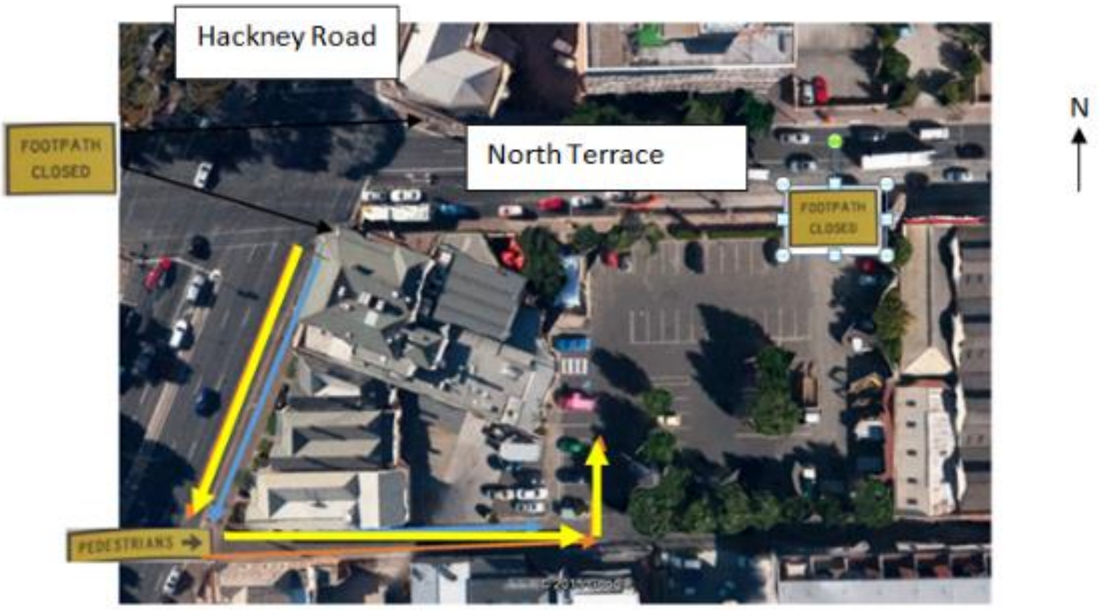

Figure 201 Pedestrian Detour-Royal Hotel

7.4.5.2. Residential Access

It was noted in Section 7.2.6 that a number of residential estates exist within the construction zone that would need to be accessed through the side streets specified in Table 68 during full closures. An example of a pedestrian detour setup to access allotments 34-46 is shown in Figure 202 where the yellow box highlights the block of residential allotments.

Figure 202 Pedestrian Detour-Residential Access

The detour shown, redirects pedestrians down Little King William Street, where the properties can be accessed from rear entrances, or side entrances through College Road.

If the residents living in the highlighted area are required to cross North Terrace during a full closure, then they may communicate with a traffic manager on site. The traffic manager will then identify an appropriate location to cross the road and assist the pedestrian.

7.4.6. Traffic Management Plan Template

A template was also developed which would be used by the contractors during construction to notify other workers and traffic controllers of traffic management which would be occurring. This is shown in Figure 203.

Traffic Management Plan

Date:______________ Name of TMP Applicant:______________________________

Start Time of Traffic Management Plan Implementation:______________________

End Time of Traffic Management Plan Implementation:_______________________

Exact Location of Works:____

____

Works to Be Completed During Implementation of Traffic Management Plan:_______

____

____

TMP Approved By (Client):____

Signature:____

Date:____________________

TMP Approved By (Traffic Control Manager):_________________________________

Signature:____

Date:____________________

Figure 203 Traffic Management Plan Template

This traffic management plan documentation would be attached to the front of any of the traffic management setups defined in Section 7.4.2, 7.4.3, 7.4.4 or 7.4.5, to provide detail of the timing of the plan and ensure the setup has been signed off by the appropriate team members and the works to be completed during the implementation of the plan are clearly defined.

7.4.7. Other Traffic and Construction Aspects

Some other aspects of traffic management and transport which should be considered as part of the detailed design are discussed below.

7.4.7.1. Reinstating Pavement

During construction works, the trench is required to be dug, and the pavement reinstated. This is required for the main pipe line, and at the four connection points to the mains. It is understood that the trench may be exposed whilst the road is open to traffic. If this occurs, before the pavement reinstatement is complete, steel plates will be used to fill the trench and provide a trafficable surface.

7.4.7.2. Construction of Retaining Wall

The retaining wall will be constructed in the Botanic Gardens. As this is outside of the construction zone, and within the garden, traffic management plans were not required to be produced. Prior to retaining wall construction, it is vital that the team contacts the Botanic Garden management, to organise any relevant pedestrian detours and discuss the most appropriate access and egress points into the garden. The team should also ensure the Botanic Garden management notifies their maintenance crews of the construction works, so scheduled maintenance and maintenance vehicle access arrangements can be arranged.

Traffic management plans for vehicles will not be required, as this location is not open to private vehicle access.

7.4.7.3. Installation of Rainwater Tanks-Slab, Tank and Connection to Stormwater

The traffic management and transport team also considered the installation of rainwater tanks, the slabs which will house the tanks and the connection from the rainwater tank to the conventional stormwater system.

It was agreed that all tanks and other required materials will be stored at the site yard. As defined in Section 7.2.6 access to most properties within the construction zone can be found at the rear of the home, through Nuffield Lane for homes located on the Northern side of North Terrace or Little King William Street for homes located on the Southern side.

Based on this it was assumed that the required vehicles and materials would be transported to each residential allotment through the use of these back streets.

7.4.7.4. Maintenance of Gross Pollutant Trap

The traffic management plan for the installation of the gross pollutant trap can be found in Section 7.4.2.2. Once installed though, this environmental element requires maintenance, approximately eight times per year. The maintenance involves using a vac truck to remove debris from the trap. This will require the closure of one lane, and a similar work zone traffic management setup can be used as described in Section 7.4.2.1 The lane closure should occur in the inter-peak or after-peak period, or during a weekend, when traffic volumes are not as high as the AM and PM peak periods. The lane closure would only need to be implemented for approximately one hour.

7.4.7.5. Disposal of Excavated Material

During construction of the trench, a significant volume of soil will be excavated. As specified in the environmental section, it has been specified that this material is not acceptable for use in back filling or in a stock pile. To remove the soil from site, the material will be transported to ResourceCo.

ResourceCo is a company which is responsible for the disposal or reuse (depending on the quality of material) of excess material. They also provide materials, such as concrete, aggregate and asphalt for other construction projects. This company was selected to be appropriate due to their closeness to site and their focus on sustainability and recycling of material.

Figure 204, below, shows the proposed route for the vehicles to transport this material to the ResouceCo site. ResourceCo is located at Lonsdale and Wingfield, though the Wingfield site was selected due to its short distance from site. This route was also considered appropriate for heavy vehicles as it utilises main arterial roads and does not require the driver to manoeuvre around tight turns or spaces.

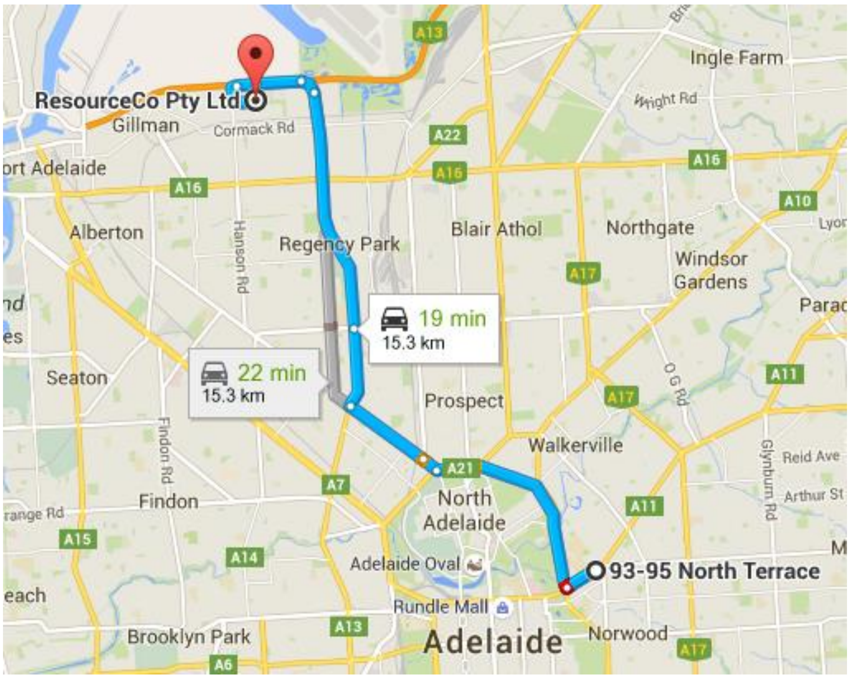

Figure 204 Directions from Site to ResourceCo

7.4.8. Costing

The Hydro Future team then contacted Work Zone Traffic Control, a traffic management company based in Hendon, South Australia, to complete the costing section of the detailed design. The costs in the following table, are based on rates provided by Work Zone Traffic Control, in their pricing list. A copy of this list can be found in Appendix, Section 4.4.

The costing was based on the time of construction of 3 months, also assuming that there will be 8 nights worth of night works (4 nights for installing connections to mains which run perpendicular to the direction of travel and 4 nights for asphalt resealing). As per the Work Zone Traffic Control Pricing Schedule, it was assumed that day works consist of 8 hours of work between 6AM and 6PM, on a weekday.

As can be seen in the pricing list provided, a cost is not given for the hire of temporary signals. To overcome this Kennards Hire at Darlington were contacted, who quoted that temporary transportable traffic signals could be hired in a set of 2 for $524 per day or $1580 per week.

Coates hire also provided the cost for temporary mesh panel fencing, which is $1/meter/week. As a maximum, it was assumed that the entire length of the construction zone (720m) would require fencing for the entire length of construction.

It should also be noted that in the costing table, the hourly rate quoted for day and night traffic zone setup includes one vehicle with a flashing arrow board, Australian Standard Class I signs, UHF radios and two traffic controllers. Though it would be less expensive if one traffic controller was used, two were quoted for due to the extensive length of the construction zone and high pedestrian and vehicle activity in the area.

The quote has also made an allowance for after care signage, which is required if signs are to be left on site during afterhours time periods. For this, it was assumed that 10 detour signs, and approximately 10 signs within the construction zone, would remain on site during the after-peak interval.

This results in the following Bill of Quantities

7.4.1. Bill of Quantities

Bill of Quantity
Client: Tonkin Consulting
Project: North Terrace Drainage Design
Department: Traffic and Transport Management

#	Item name	Catalogue reference or special specification (if needed)	Unit	Quantity	Rate	Cost ($)
			Subject: Traffic and Transport Management			
1	Setup work zone for day works	NA	hours	360	$108/hr	$38,880
2	Setup work zone for night works	NA	hours	64	$142/hr	$9,088
3	Hire of temporary signals	NA	weeks	9	$1580/ week	$14,220
4	After care signage	NA	signs	10 detour signs for 8 nights + 10 constructi on signs for 45 days	$2/sign/ day	$2,120
5	Temporary fencing	NA	Meter/week	720m for 9 weeks	$1/mete r/week	$6,480
			Sub-total (1)			**$70,788**
			Subject: Unplanned Traffic Control (Optional)			
	Unplanned traffic control	NA	hours	Number of hours is arbitrary	$85 call out fee + standar d rate	

7.4.2. Safety and Training

There are certain transport and traffic safety risks which are posed during the construction stage. These are identified below and mitigation strategies are described.

Task Specific Safety Assessment Form	
Department/Section:	**Traffic and Transport Management**
Task/ stage Name:	Construction of Detailed Design
Brief Description of works to be undertaken	
• Setup of work zones in the construction zone – placement of signs, cones, temporary fences and barriers • Setup of site office and storage yard • Relocation of bus stops • Setup of detour routes – placement of signs, cones, temporary fences, temporary signals and barriers • Notification of works to businesses and residents • Notification of works to emergency services and Adelaide Metro	
Summary of major risks or hazards	
• Traffic controllers working close to live traffic • Presence of increased volumes of heavy vehicles in a high access pedestrian area • Transport of heavy materials and the use of cranes • Minimal distance between construction zone and pedestrian areas • Exposure to weather and dehydration	
Mitigation strategies	
• Workers undergo appropriate training and site induction • Site safety officer will be on site at all times • Flashing lights will be installed on each work vehicle • Use of barriers and temporary fences to separate pedestrians from construction area	

• **Visible site office and material yard that has appropriate signage to ensure pedestrians do not enter without being escorted onto site from trained personnel** • **High visibility work wear, hard hats, safety glasses and steel cap shoes will be worn by all workers at all times** • Depending on the machinery used, earplugs will be provided to workers • Use of advanced warning signs to provide notification of the works to drivers, before they drive past the work zone • The use of UHF radios to ensure there is clear and constant communication between workers on site • Long sleeved pants and tops will be worn by workers at all times to prevent sunburn. Sunscreen and filtered water will also be provided, free of charge, to each worker at the site office.
Safety equipment required & number
• Signage, temporary signals, cones and barriers – dependent on workzone setup • Hard hats, safety glasses, steel cap boots and high visibility vests – one per worker

The training for each worker was also analysed, for people working during the construction of this project. The following list outlines training requirements:

- Induction: A site specific induction will be run by the safety team for each worker (including transport staff) who is operating on site. This will outline safety procedures specific to the project, outline procedure for emergency situations
- White Card Training Course: Each employee will not be permitted onto site unless they have previously completed their white card training course. This is a one day course which outlines general safety procedures.
- Tickets and Licenses: Each worker operating any machinery on site will require the relevant training, and this is presented through the appropriate ticket. Similarly, any worker on site operating a vehicle much hold an Australian Driver’s License.
- Work Zone Traffic Management Course: Each traffic management operator would have completed this course. This can typically be completed in one day and outlines how to setup safe work zones, how to operate a stop/slow bat and other traffic management details.