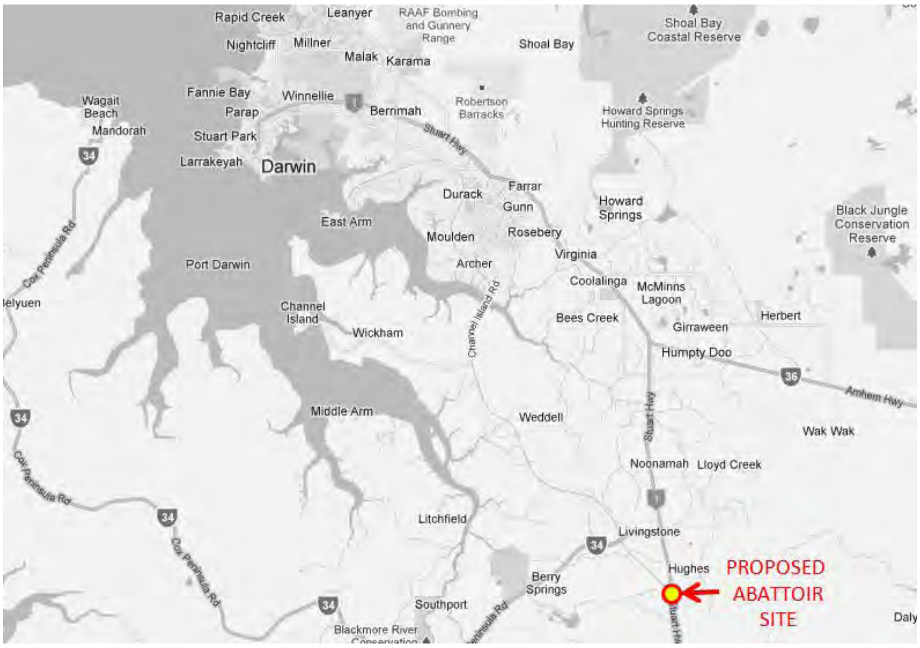
Annexure 5

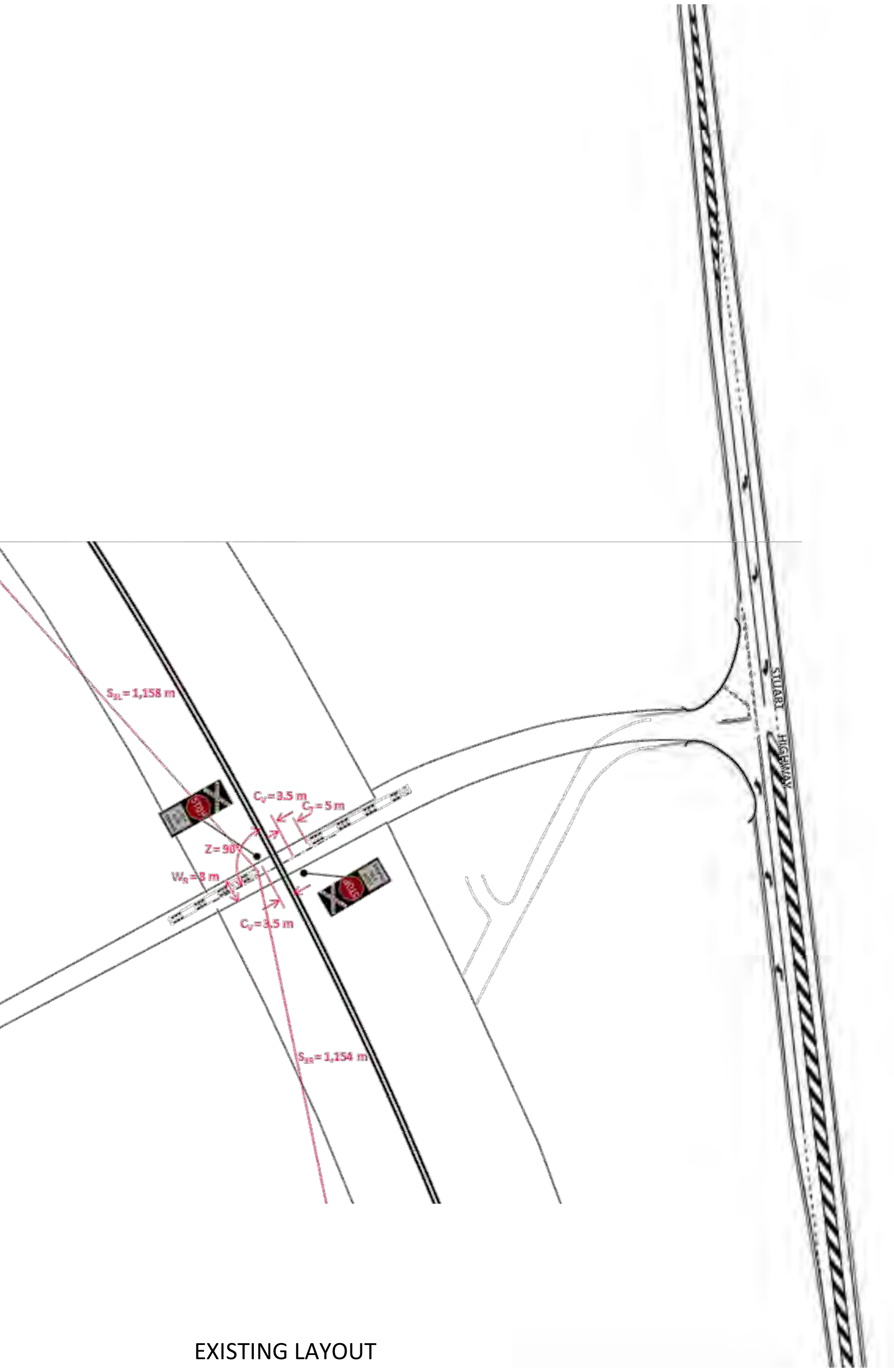
Traffic Impact Study



Prepared for:

Northern Australia Beef Ltd.

Darwin Abattoir, Livingstone



EXISTING LAYOUT

Traffic Impact Study

Final 1.1

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Project details

Project ID	26101
Client	Northern Australia Beef Ltd.
Description	i3 consultants (i3) has been commissioned by Northern Australia Beef Ltd (NABL) to undertake a traffic impact study for a proposed Abattoir on the east side of Stuart Highway near Livingston approximately 50 km south of Darwin. The traffic impact study has been carried out in accordance with the Austroads document Guide to Traffic Management Part 12: Traffic impacts of Developments.

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	MS Office WindowsLive access available to registered personnel only							

v1.1 – minor amendment to Section 2.3 to better reflect current use of site (i.e. grazing and fodder production).
This is not an approved document unless certified here.

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CONTENTS

1. INTRODUCTION

1.1 THE COMMISSION

i3 consultants (*i3*) has been commissioned by Northern Australia Beef Ltd. to undertake a traffic impact study for a proposed abattoir on the east side of Stuart Highway near Livingston approximately 50 km south of Darwin as shown in **Figure 1**. The traffic impact study has been carried out in accordance with the Austroads document *Guide to Traffic Management Part 12: Traffic impacts of Developments*.

Figure 1 – Location of proposed development

1.2 SCOPE OF WORK

The scope of works involves:

1. Provision of traffic engineering, road safety and transport planning advice to MEATENG during the preparation of the development application;

2. Determination of likely vehicle trips to be generated by the proposed development;

3. Distribution of vehicular traffic onto and off Stuart Highway as a result of the development;

4. Determination of traffic growth scenarios, including base (road network) traffic;

5. Preparation of a micro-analytical traffic model (*SIDRA Intersection*[(1)]) for the proposed development access intersection with Stuart Highway, including the railway crossing, and assessment of key intersection performance criteria such as Average Delay, Queue Lengths, Degree of Saturation and Level of Service.

6. Assessment of appropriateness or otherwise of the current intersection layout and, if necessary, recommended control and layout to suit the forecast model prepared above.

7. Assessment of the rail crossing in accordance with *AS1742.7*[(2)] and Austroads documents *Guide to Road Design Part 4: Intersections and crossings – General*[(3)] and *Guide to Road Design Part 4A: Unsignalised and Signalised Intersections*[(4)] including determination of appropriate control.

Preparation of a supporting Traffic Report documenting all of the above for inclusion with the development application.

2. BACKGROUND INFORMATION

2.1 SITE DESCRIPTION

The site is located on the west side of Stuart Highway just north of the Livingstone WWII airstrip (approximately 50 km south of Darwin) as shown in **Figure 2**.

Site access is to be via the existing access point and associated intersection layout with a realigned access road and rail crossing, as shown in **Figure 2**.

Figure 2 – Current and proposed site access off Stuart Highway

2.2 NORTHERN TERRITORY PLANNING SCHEME (*NTPS*) PARKING REQUIREMENTS

Section 6.5.1 of the *NTPS*[(5)] requires, with respect to an 'abattoir', a minimum parking provision of 1 car parking space for every 100 m^2 of net floor area other than offices plus 4 for every 100 m^2 of net floor area of office. The parking requirement for a 'community centre' is 5 for every 100 m^2 of net floor area.

"net floor area" in relation to a building, includes all the area between internal surfaces of external walls but does not include:

a) stairs, cleaners cupboards, ablution facilities, lift shafts, escalators or tea rooms where tea rooms are provided as a standard facility in the building;
b) lobbies between lifts facing other lifts servicing the same floor;
c) areas set aside as public space or thoroughfares and not used exclusively by the occupiers of the building;
d) areas set aside as plant and lift motor rooms;
e) areas set aside for use of service delivery vehicles; and
f) areas set aside for car parking or access.

2.3 EXISTING DEVELOPMENT

The existing use of the subject land is for cattle grazing and fodder production (refer **Photograph 1**) with an advised associated average traffic movement of 1 to 2 semi trailers per week. No movements were observed during the site visit.

Photograph 1 – looking west at current access to the development site (from the west side of the existing rail crossing)

2.4 PROPOSED DEVELOPMENT

Northern Australia Beef Ltd. has indicated that the proposed abattoir development is likely to process between 240 and 1,040 livestock per day.

An estimate of likely traffic movements prepared by Meateng is provided as Table 1.

Processing Tally		**240**		**360**		**520**		**760**		**760**		**1040**
Manning		80		110		165		245		275		330
Cars / Vans	65%	48		67		100		148		167		200
Livestock Transport		2.5		3.25		4.25		5.75		5.75		7.5
Finished Product Transport		5.4		7.6		10.6		15.0		15.0		20.1
Trades / Services / Contractors		6		6		6		15		15		15
Community Centre		10		10		15		20		20		30
Total Vehicle Movements (Day)		**72.4**		**93.5**		**135.8**		**204.2**		**222.4**		**272.6**

Daily Profile	**1040 Tally**	**5:00 6:00**	**6:00 7:00**	**8:00 9:00**	**10:00 12:00**	**12:00 14:00**	**14:00 15:00**	**15:00 17:00**	**17:00 19:00**	**19:00 21:00**	**21:00 23:00**	**23:00 1:00**
Cars / Vans		90	20	10	10	10	190	30				100
Livestock					2	4		4	4	2		
Finished Product			4	6	6	6		6	4	4	4	
Trades Contractors		6		2		2		12		2		6
Total Vehicle Movements (Day)		**96.0**	**24.0**	**18.0**	**18.0**	**22.0**	**190.0**	**52.0**	**8.0**	**8.0**	**4.0**	**106.0**

Table 1 – Estimated traffic generation (daily and time of day)

NABL has indicated that the development will have a total net floor area (NFA) of 10,961 m^2 and accommodate up to 176 personnel during any one shift. There will also be a community centre of 700 m^2 NFA. A breakdown of these details is provided in Table 2 with the layout shown on the Development Drawing included at **Appendix A**.

People Occupancy - Darwin Abattoir														
Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total pa
Calendar Days per Mth		31	28	31	30	31	30	31	31	30	31	30	31	
Production Days per Mth		11	11	21	21	21	21	21	21	21	21	21	20	231
Production Head per Day		520	520	520	1040	1040	1040	1040	1040	1040	1040	1040	520	
Shifts		1	1	1	2	2	2	2	2	2	2	2	1	
	Area (m2)													
Slaughter Personnel	613	45	45	45	45	45	45	45	45	45	45	45	45	
Boning Room Personnel	1,340	70	70	70	70	70	70	70	70	70	70	70	70	
Carcass Chiller	964													
Carton Store	371													
Cold Store/Load Out Personnel	3,300	11	11	11	11	11	11	11	11	11	11	11	11	
Render/ Hides Personnel	1,400	5	5	5	5	5	5	5	5	5	5	5	5	
Plant Ancillary Personnel		45	45	45	45	45	45	45	45	45	45	45	45	
Administration	230													
Laundry/ First Aid	160													
Amenities	518													
Lunch/ Offices	307													
Entry Booth	15													
Truck Dispatch Booth	45													
Engine Room	350													
Workshhop	648													
Total Area (m2)	10,961													
Total Persons/ shift		176	176	176	176	176	176	176	176	176	176	176	176	

People Occupancy - Community Center														
Community Center														
Total Area (m2)	700													
Total Occupancy		TBA												

Table 2 – Development Details – m^2 *NFA* and personnel

3. ASSESSMENT

3.1 EXISTING PROPOSALS FOR IMPROVEMENTS TO THE ADJACENT ROAD NETWORK AND HIERARCHY

There are no known existing proposals for improvements to Stuart Highway or changes to the current road network hierarchy.

Stuart Highway is a major arterial road (National Highway 1) and is the only sealed north-south link crossing central Australia. Running between Port Augusta and Darwin's East Arm Port, it is also the only sealed link for the AusLink Adelaide-Darwin corridor's major centres of Darwin, Katherine, Tennant Creek, Alice Springs, Coober Pedy and Port Augusta(6).

3.2 IMPACT ON ROAD SAFETY

The existing access arrangement (as shown in **Figure 3**) is described as an Auxiliary Lane Turn Treatment (Type AU).

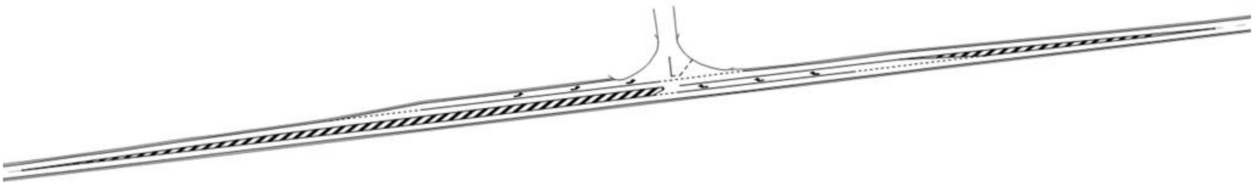


Figure 3 – Existing access arrangement (AUR/ AUL)

The AU turn treatment has short lengths of auxiliary lane provided to improve safety, especially on high-speed roads. It comprises the following turn treatments:

- auxiliary right-turn treatment (AUR) on the major road (provided)
- auxiliary left-turn treatment (AUL) on the major road (provided)
- auxiliary left-turn treatment (AUL) on the minor road (not provided)

While AUR turn treatments exist at many locations and are safer than a basic treatment they are not as safe as channelised treatments (i.e. CHR) to protect right-turners. They are therefore not favoured by some jurisdictions (e.g. Queensland Department of Main Roads and the New Zealand Transport Agency) for use as new unsignalised intersections. As discussed below, the same situation applies with respect to the use of AUL turn treatments.

Often, not all of the treatments will be used together at a single intersection. The AUR right-turn treatment:

- allows traffic to bypass a vehicle waiting to turn right, or may provide a lane for left-turning traffic, or both
- can only be used on legs which have a sealed surface
- can be confused with an auxiliary lane for overtaking and should only be used at locations where the driver can appreciate the purpose of the lane. Situating such intersections near auxiliary lanes used for overtaking must be avoided.

- has been used where an arterial road meets with sub-arterials, collectors, or local roads (particularly in rural areas where there is a low volume of high speed through traffic and the volume of turning traffic is sufficient to make a conflict likely)
- is more expensive than basic intersections, but can be more cost-effective when long-term crash costs are included in the economic analysis.

Research has shown that the crash rate for vehicles entering the major road from the minor road at an unsignalised intersection is significantly higher when there are two stand-up lanes on the minor road (i.e. when there is an auxiliary lane) because a vehicle standing in the right lane obscures the view of drivers in the left lane and vice versa (refer Figure 4). For this reason an AUL turn treatment on the minor road is not preferred at rural or urban sites, particularly at four-way unsignalised intersections. It is therefore desirable that the minor road approach has only one stand-up lane and, if sufficient traffic demand exists, that a channelised left-turn treatment is provided.[(7)]

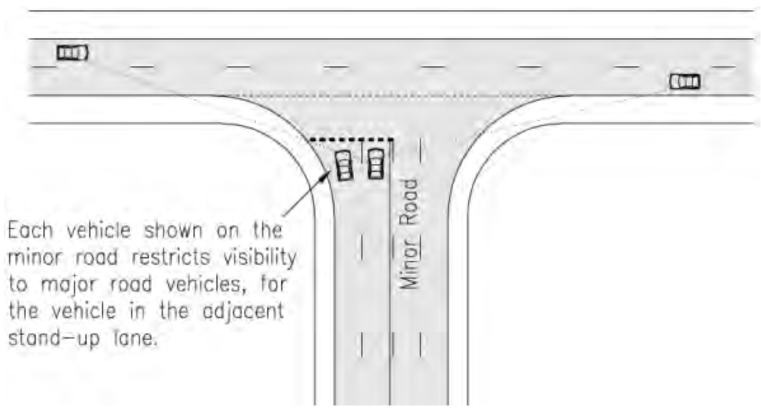


Figure 4 - Restricted visibility at an unsignalised intersection comprising two stand-up lanes on the minor road (Source Fig 4.4 *AGRD04A/09*[(7)])

An assessment of the existing arrangement based on the above criteria, and subject to assessment of capacity performance related to increased traffic volumes and turning movements (refer **Section 3.4**) indicates that this is an appropriate layout.

3.3 EXAMINE VOLUMES AND HISTORICAL TRENDS ON KEY ADJACENT ROADS

The nearest permanent count station of Stuart Highway relevant to the development site is RDVDP002, located 2 km north of Manton Dam turnoff, i.e. approximately 12 km south of the development site. Data at this count site is considered appropriate as there are no major attractors/ generators or intersections between the development site and the count station that would result in significant differences.

An analysis of the data from the *Annual Traffic Report 2009*[(8)] has revealed that the current volumes are in the order of 1,000 vehicles per day in each direction, i.e., a total of approximately 2,000 vehicles per day. Further analysis of data over the last 10 years indicates that this is likely to grow to around 2,400 vehicles per day (or 1,200 vehicles per day in each direction) by 2015, the adopted assessment year for this *TIS*. This represents an annual growth rate of 2%. This data is shown in **Figure 5** on the following page.

		ADT	Station	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Stuart Hwy	2 km north of Manton Dam Turn Off	RDVDP002	northbound	908	885	924	871	822	870	917	1,057	1,099	1,086
			southbound	867	859	919	867	796	829	898	1,035	1,077	1,065
			Total	1,775	1,744	1,843	1,738	1,618	1,699	1,815	2,092	2,176	2,151

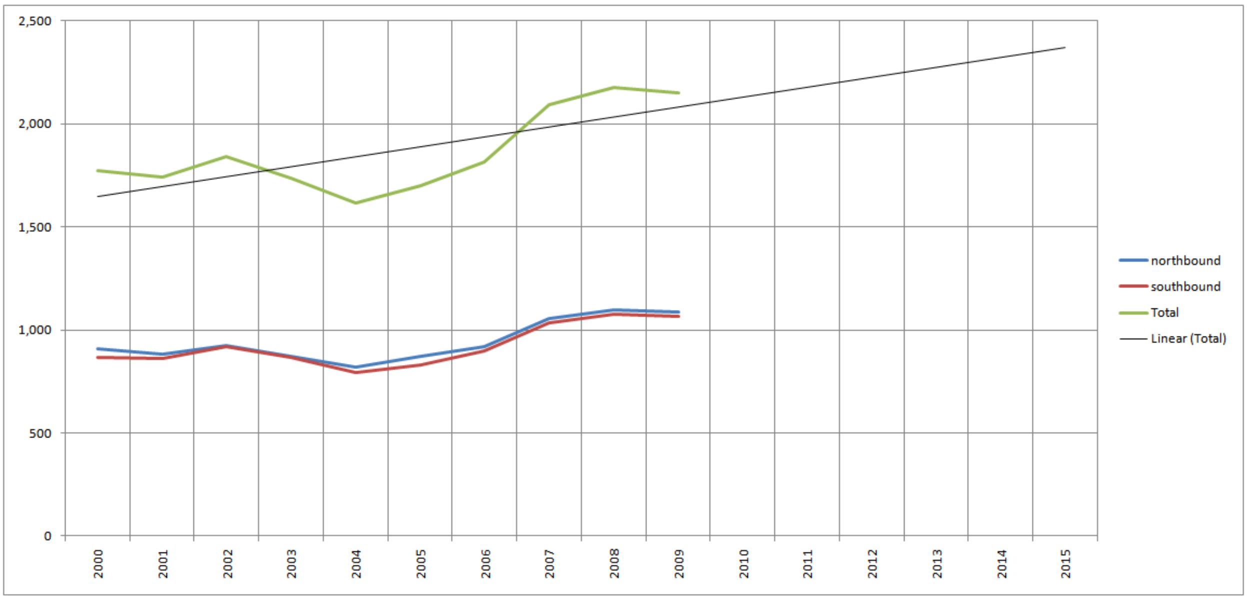


Figure 5 – Average Annual Daily Traffic (AADT) Volumes – Stuart Highway 2 km north of Manton Dam Turn Off

An analysis of the classification of vehicles (i.e. cars, heavy vehicles, long vehicles, road trains etc...) has revealed light vehicles make up approximately 78% of the daily traffic with the remaining 22% made up of heavy traffic. A more detailed breakdown is provided in **Table 3**.

STUART HIGHWAY 2 km north of Manton Dam Turn Off
Annualised 2009 Data

VEHICLE CLASSIFICATION SYSTEM
AUSTROADS

CLASS		NORTHBOUND %	SOUTHBOUND %	COMBINED %
	TOTAL	100.0%	100.0%	100.0%
	LIGHT VEHICLES	68.8%	87.9%	78.3%
1	SHORT Car, Van, Wagon, 4WD, Utility, Bicycle, Motorcycle	62.7%	80.4%	71.4%
2	SHORT - TOWING Trailer, Caravan, Boat	6.2%	7.6%	6.9%
	HEAVY VEHICLES	27.1%	8.0%	17.6%
3	TWO AXLE TRUCK OR BUS *2 axles	22.3%	4.2%	13.3%
4	THREE AXLE TRUCK OR BUS *3 axles, 2 axle groups	0.9%	1.7%	1.3%
5	FOUR (or FIVE) AXLE TRUCK *4 (5) axles, 2 axle groups	0.2%	0.4%	0.3%
6	THREE AXLE ARTICULATED *3 axles, 3 axle groups	1.6%	0.3%	1.0%
7	FOUR AXLE ARTICULATED *4 axles, 3 or 4 axle groups	1.3%	0.5%	0.9%
8	FIVE AXLE ARTICULATED *5 axles, 3+ axle groups	0.2%	0.3%	0.3%
9	SIX AXLE ARTICULATED *6 axles, 3+ axle groups or 7+ axles, 3 axle groups	0.6%	0.6%	0.6%
	LONG VEHICLES AND ROAD TRAINS	4.1%	4.1%	4.1%
10	B DOUBLE or HEAVY TRUCK and TRAILER *7+ axles, 4 axle groups	0.3%	0.3%	0.3%
11	DOUBLE ROAD TRAIN *7+ axles, 5 or 6 axle groups	1.1%	1.2%	1.1%
12	TRIPLE ROAD TRAIN *7+ axles, 7+ axle groups	2.7%	2.6%	2.7%

Table 3 – Percentage classification of current Stuart Highway traffic volumes

3.4 PEAK PERIOD TRAFFIC VOLUMES AND CONGESTION LEVELS AT KEY ADJACENT INTERSECTIONS (INCLUDING SIDRA MODELLING)

The existing intersection (the only 'Key Adjacent Intersection') appears to provide access to farmland only and was not observed to be used during the two hour site visit. There is evidence of it being used on a regular, if not frequent, basis. For the purpose of the assessment, one 'farm trip' IN and OUT has been added to existing and forecast peak hour traffic intersection models.

3.5 EXISTING PARKING SUPPLY AND DEMAND IN THE VICINITY OF THE PROPOSED DEVELOPMENT

There is no existing formal parking supply or demand due to the remote rural nature of the existing site.

3.6 EXISTING AND PROPOSED PUBLIC TRANSPORT SERVICES IN THE VICINITY OF THE PROPOSED DEVELOPMENT

There are no existing public transport services in the vicinity of the proposed development site due to the remote rural nature of the existing site.

3.7 PARKING PROVISIONS APPROPRIATE TO THE DEVELOPMENT (IN RELATION TO DEMAND AND STATUTORY REQUIREMENTS)

The Development Drawing indicates that there will be a total parking provision of 239 car bays. An assessment of parking requirements and provision is shown in **Table 4**. Although this indicates that there is a 'shortfall' of 9 bays for the community centre it is very likely that the Community Centre will be visited by foot by persons who have already parked their vehicle in the abattoir car park. The overall provision of 239 bays is 111 bays more than technically required under the *NTPS*.

	NFA	NTPS Requirement (per 100m^2)	Bays Required	Bays Provided	
Slaughter	613	1	6.1	213	
Boning	1340	1	13.4		
Cold Store	3300	1	33.0		
Render/ Hides	1400	1	14.0		
Admin	230	1	2.3		
Amenities	518	1	5.2		
Offices	307	4	12.3		
Workshop	648	1	6.5		
Community Centre	700	5	35.0	26	
Rounded up Totals					
Abattoir			93	213	Excess
Community Centre			35	26	Shortfall
TOTAL			**128**	**239**	Excess

Table 4 – Parking Bay Assessment

Whilst the above is an assessment against the *NTPS* requirements, it may not necessarily be indicative of the demand for parking.

In order to encourage car pooling and hence reduce trips to and from the abattoir, which in turn reduces trips across the rail crossing and hence reduces the likelihood of conflict, it is necessary to avoid the 'predict and provide' method of parking provision.

An assessment of the proposed provision of 213 parking bays for a shift workforce of 176 persons has been carried out and is shown in **Table 5**. The '70% coincides' data takes into account that during the shift change it is likely that up to 70% of the vehicles in the car park for one shift will still be there when the vehicles for the next shift arrive.

Persons per shift	176
Persons present at shift change (Assuming 70% coincides)	299
Abattoir bays provided	213
Equivalent persons/ bay	1.4

Table 5 – Personnel parking provision assessment

Table 5 indicates that there is adequate parking provision based on the 70% shift coincidence and up to 40% of shift workers sharing the trip with another co-worker. The assessment does not take into account shift workers who are dropped off or if a bus service is provided in which case parking provision is higher.

From a *NTPS* and pragmatic demand assessment viewpoint, the proposed parking provision is deemed to be appropriate.

3.8 TRAFFIC GENERATION/ ATTRACTION AND DISTRIBUTION OF THE PROPOSED DEVELOPMENT

The trip generation data in **Table 1** on page 7 indicates that light vehicle peak hour trip generation is likely to occur between 14:00 (2 PM) and 15:00 (3 PM), with a total of 190 trips and heavy vehicle peak hour trip generation is likely to occur between 15:00 (3 PM) and 17:00 (5PM) with a total 2-hour volume of 30 cars and 22 heavy vehicles. It is therefore appropriate to adopt the following two assessment peak hours:

- Light vehicle peak hour: 2 PM to 3 PM weekdays
- Heavy vehicle peak hour: 4 PM to 5 PM weekdays (assuming half the two-hour volumes)

There is no breakdown of daily volumes into hourly volumes for Stuart Highway traffic at this location. Recent surveys elsewhere, e.g. Coolalinga, has indicated that peak hour volumes on Stuart Highway usually occur between 7.30 and 8.30 am and 4.30 to 5.30 PM are approximately 10% of the daily volume. For the purpose of assessment, a peak hour volume of 10% of the daily volumes on Stuart Highway has been used to determine the likely 2009 volumes for each assessed peak hour as shown in **Figure 6** and **Figure 7** on the following pages. *SIDRA Intersection*[(1)] models based on this data have also been prepared with the results and assessment discussed in the pages following these figures.

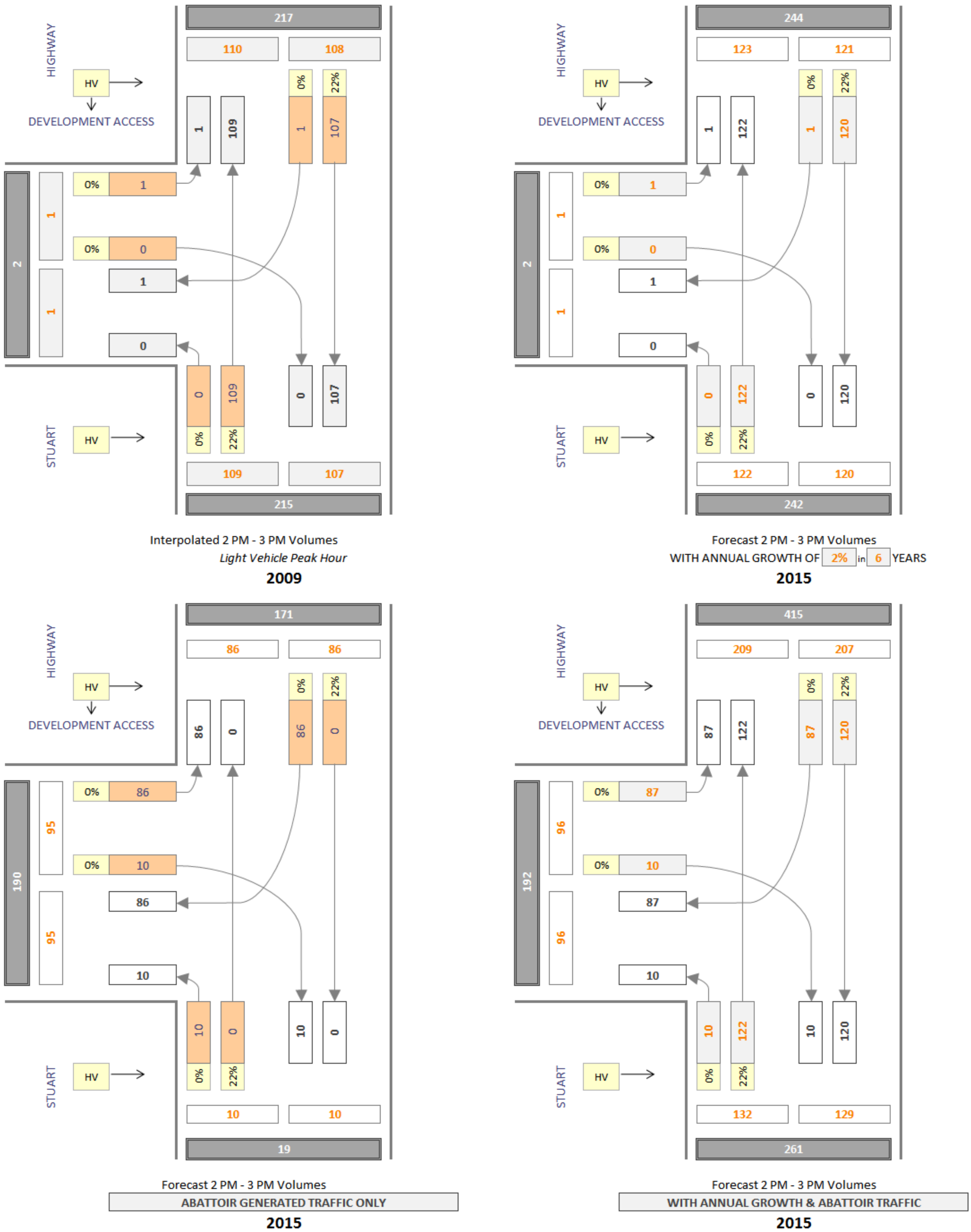


Figure 6 – Calculation of existing and forecast turning volumes: Light Vehicle Peak Hour

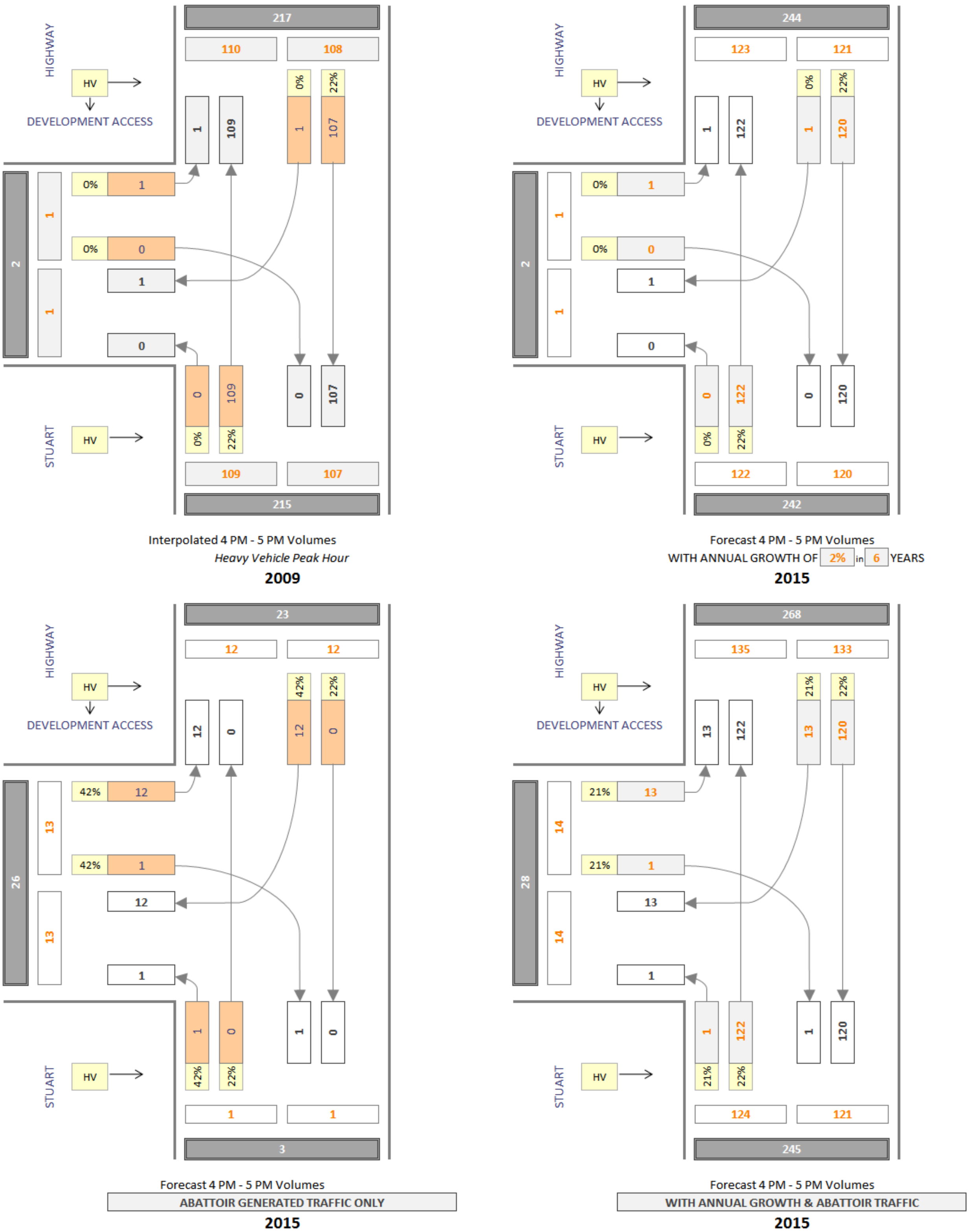


Figure 7 – Calculation of existing and forecast turning volumes: Heavy Vehicle Peak Hour

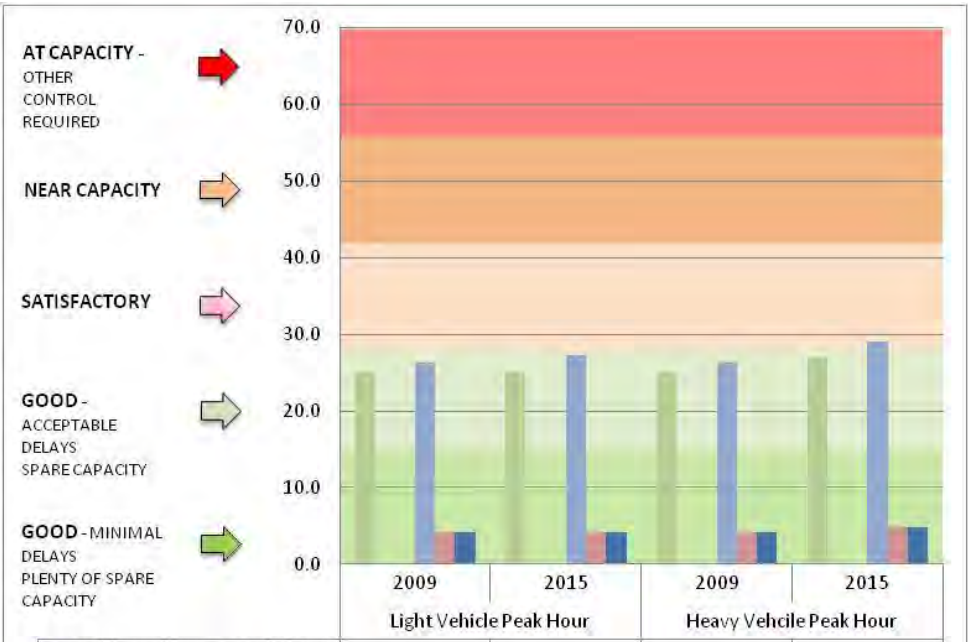
The following assessment of intersection capacity, based on Average Delay (which is considered to be the best indicator of intersection performance in terms of safety) is based on the *SIDRA Intersection*[1] reports included in **Appendix B**.

Intersection performance threshold criteria are provided in Table 6.

Level of Service (LoS)	Average Delay per Vehicle (secs/veh)	Traffic signals & Roundabouts	Give Way & Stop Signs
A	<14	Good operation.	Good operation.
B	15 TO 28	Good with acceptable delays and spare capacity.	Acceptable delays & spare capacity.
C	29 – 42	Satisfactory.	Satisfactory, but crash study required.
D	43 – 56	Operating near capacity.	Near capacity and crash study required.
E	57 - 70	At capacity; at signals incidents will cause excessive delays. Roundabouts require other control measure.	At capacity. Requires other control mode.

Table 6 - Level of service criteria for intersections (source Table 4.2[9])

The assessment of expected average delay for each movement with the forecast trips to and from the abattoir (shown graphically against acceptable performance criteria in **Figure 8**) indicates that the intersection has sufficient spare capacity to accommodate the forecast turning movements and volumes.



	Light Vehicle Peak Hour 2009	Light Vehicle Peak Hour 2015	Heavy Vehcile Peak Hour 2009	Heavy Vehcile Peak Hour 2015
Northbound Stuart Hwy left into Access	25.0	25.0	25.0	26.9
Northbound Stuart Hwy straight through	0.0	0.0	0.0	0.0
Southbound Stuart Hwy striaght through	0.0	0.0	0.0	0.0
Southbound Sturt Hwy right into Access	26.3	27.3	26.3	29.0
Access left into Stuart Hwy	4.2	4.2	4.2	4.8
Access right into Stuart Hwy	4.2	4.2	4.2	4.8

Figure 8 – Assessment of Intersection Performance (Average Delay)

3.9 SAFETY AND EFFICIENCY OF ACCESS BETWEEN THE SITE AND THE ADJACENT ROAD NETWORK

Whilst **Section 3.9** has indicated that the intersection has sufficient spare capacity to accommodate the forecast trips, it is still deemed necessary to undertake a check of the available sight distance at the intersection to assess whether or not it can operate within safe parameters.

The posted speed limit on both Stuart Highway approaches is 110 km/h although this changes to 130 km/h south of the abattoir access intersection. Observations on site (by joining the free flowing traffic stream) indicated that approach speeds are closer to 120 km/h than 110 kmh. It is therefore deemed appropriate to use an approach speed of 120 km/h in the assessment of available sight distance.

The types of sight distance that must be provided in the design of all intersections include:

- approach sight distance (*ASD*)
- safe intersection sight distance (*SISD*)
- minimum gap sight distance (*MGSD*).

Intersections should be designed to provide the more conservative value of *SISD* or *MGSD* for all vehicle movements that may be required to give way to other vehicles at the intersection. Details regarding how these sight distances are applied are provided in the following sections.

3.9.1 Approach Sight Distance (*ASD*)

Provision of *ASD* for cars is:

- the minimum level of sight distance which must be available on the minor road approaches to all intersections to ensure that drivers are aware of the presence of an intersection;
- also desirable on the major road approaches so that drivers can see the pavement and markings within the intersection and should be achieved where practicable. However, the provision of *ASD* on the major road may have implications (e.g. cost; impact on adjacent land and features) in which case Stopping Sight Distance (*SSD*) is the minimum sight distance that should be achieved on the major road approaches to the intersection and within the intersection;
- numerically equal to normal car *SSD* – which is defined as the distance travelled by a vehicle between the time when driver receives a stimulus signifying a need to stop, and the time the at which the vehicle comes to rest; and
- different from *SSD* in the object height used in its calculation. *ASD* is measured from a driver's eye height (1.1 m) to 0.0 m, which ensures that a driver is able to see any line marking and kerbing at the intersection whereas *SSD* is measured from 1.1 m to 0.2 m (a nominal object height).

Provision of ASD for trucks

The various sight distance requirements discussed above apply to cars. *ASD* for trucks should be provided at intersections to ensure that trucks approaching the intersection, at the 85th percentile operating speed of trucks, are able to stop safely. *ASD* for trucks on intersection approaches should be measured from truck driver eye height (2.4 m) to pavement level at the stop or holding line (0.0 m).

Approach sight distances for trucks are numerically the same as the *SSD* values for trucks provided in the Austroads Document *Guide to Road Design – Part 3: Geometric Design*(10).

ASD is applied as shown in **Figure 9**.

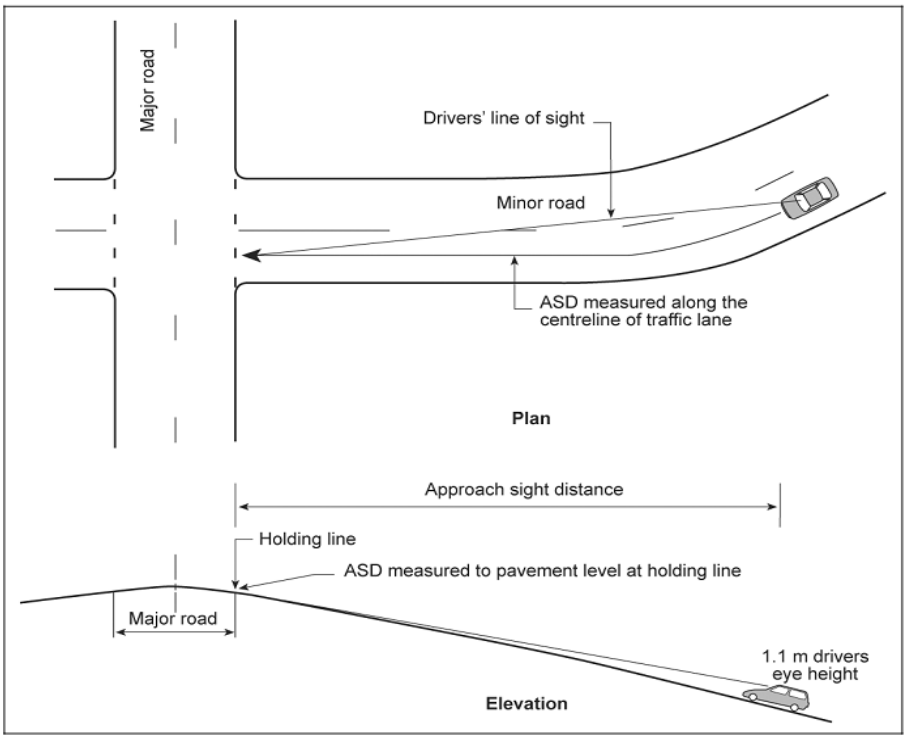


Figure 9 – Application of ASD (Source Figure 3.1 *AGRD04A/09*)

On-site measurements indicate that due to a small radius bend on the existing access approach road (refer **Photograph 2** on the following page) *ASD* is limited to 50 m. The required *ASD* is 40 m (as shown in **Calculation 1**). Despite the existing arrangement being deemed to be satisfactory, it is proposed to re-align the access road to remove the existing small radius bend and to cross the railway at right angles (as shown in Figure 2 on page 6). This will improve sight lines even further.

$$ASD = \frac{R_T \times V}{3.6} + \frac{V^2}{254 \times (d + [0.01 \times a])}$$

ASD	=	Approach sight distance (m)		
R_T	=	reaction time (s)	=	2.5
V	=	operating (85%ile) speed (km/h)	=	30
d	=	coefficient of deceleration	=	0.2
a	=	longitudinal grade (%: +uphill, -downhill)	=	0.0 %

$$ASD = \frac{2.50 \times 30}{3.6} + \frac{900}{254 \times (0.22 + [0.01 \times 0])}$$

$$ASD = 20.8333 + 16.1059$$

***ASD* = 37** Rounded to **40** metres

then:

d_1 = *reaction distance* $= \frac{2.5 \times 30}{3.6} =$ 21 m

d_2 = *braking distance* $= \frac{900}{254\,(0.29 + (0.01 \times 0.0))} =$ 12 m

and:

SSD = $d_1 + d_2$ = 21 + 12 = 33 metres

SSD = $d_1 + d_2$

d_1 = *reaction distance* $= \frac{R_T \times V}{3.6}$

d_2 = *braking distance* $= \frac{V^2}{254\,(F_1 + 0.01\,G)}$

R_T = reaction time (2 seconds for urban roads)

V = operating speed (km/h)

F_1 = longitudinal friction factor (Table 8.2 URD)

Calculation 1 – Required *ASD* for cars (left) and trucks (right)

Photograph 2 – Access road approach to Stuart Highway – bend restricts vision to the intersection to approximately 50 m.

3.9.2 Safe Intersection Sight Distance (*SISD*)

SISD is the minimum distance which should be provided on the major road at any intersection.

Traffic engineers reviewing this report should note that the object height for the application of *SISD* has been increased to 1.25 m (previously driver eye height was used i.e. 1.1 m) based on research by the Queensland Department of Main Roads[11]. The basis of the 1.25 m object height cars is that this height is 0.2 m less than the 15th percentile height of passenger cars (1.45 m) as determined by the study.

SISD:

- provides sufficient distance for a driver of a vehicle on the major road to observe a vehicle on a minor road approach moving into a collision situation (e.g. in the worst case, stalling across the traffic lanes) and to decelerate to a stop before reaching the collision point;
- is viewed between two points to provide inter-visibility between drivers and vehicles on the major road and minor road approaches. It is measured from a driver eye height of 1.1 m above the road to points 1.25 m above the road which represents drivers seeing the upper part of cars. **Figure 10** on the following page illustrates the longitudinal section for the two cases representing inter-visibility; one for drivers on the major road and the second for a driver waiting in the minor road for an opportunity to enter the major road;
- assumes that the driver on the minor road is situated at a distance of 5.0 m (minimum of 3.0 m) from the lip of the channel or edge line projection of the major road. *SISD* allows for a 3 second observation time for a driver on the priority legs of the intersection to detect the problem ahead, (e.g. car from minor road stalling in through lane) plus the *SSD*;
- should also be provided for drivers of vehicles stored in the centre of the road when undertaking a crossing or right-turning movement;
- enables approaching drivers to see an articulated vehicle, which has properly commenced a manoeuvre from a leg without priority, but its length creates an obstruction; and
- is measured along the carriageway from the approaching vehicle to the conflict point, the line of sight having to be clear to a point 5.0 m (3.0 m minimum) back from the holding line or stop line on the side road.

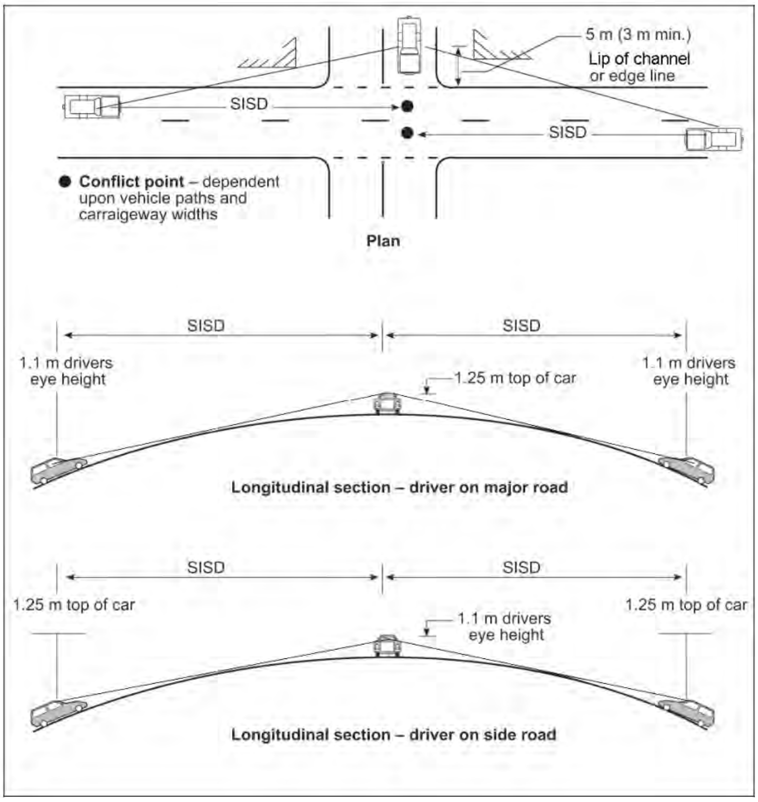


Figure 10 – Application of SISD (Source Figure 3.2 AGRD04A/09)

Where practicable, designers should provide a larger sight distance than *SISD*. The shortest available *SISD* on site is that between vehicles leaving the access and vehicles travelling north on Stuart Highway (as shown in **Photograph 3**). On-site measurements indicate that due to a crest, *SISD* is limited to 480 m. The required *SISD* is 442 m (as shown in **Calculation 2**). This is therefore deemed satisfactory.

Photograph 3 – Looking south from the abattoir access at Stuart Highway

$$SISD = \frac{D_T \times V}{3.6} + \frac{V^2}{254 \times (d + [0.01 \times a])}$$

SISD	=	Stopping sight distance (m)		
D_T	=	decision time (s) = observation time (3s) + reaction time	=	5.5
V	=	operating (85%ile) speed (km/h)	=	120
d	=	coefficient of deceleration	=	0.2
a	=	longitudinal grade (%: +uphill, -downhill)	=	0

$$SSD = \frac{5.50 \times 120}{3.6} + \frac{14400}{254 \times (0.22 + [0.01 \times 0])}$$

$$SSD = 183.3333 + 257.6951$$

$$\mathbf{SSD = 442}$$

Calculation 2 – Required *SISD*

3.9.3 Minimum Gap Sight Distance (*MGSD*)

MGSD is based on distances corresponding to the critical acceptance gap that drivers are prepared to accept when undertaking a crossing or turning manoeuvre at intersections. Typical traffic movements are shown in **Figure 11** and **Figure 12**. Information on gap acceptance theory in relation to intersection capacity is provided in the Austroads *Guide to Traffic Management – Part 3: Traffic Studies and Analysis*.

MGSD is:

- shown as 'D' in **Figure 11** and **Figure 12**
- measured from the point of conflict (between approaching and entering vehicles) back along the centre of the travel lane of the approaching vehicle
- measured from a point 1.1 m (driver's eye height) to a point 0.65 m (object height – typically a vehicle indicator light) above the travelled way.

The MGSD required for the driver of an entering vehicle to see a vehicle in the conflicting streams in order to safely commence the desired manoeuvre is dependent upon the:

- length of the gap being sought (critical acceptance gap time t_a)
- observation angle to approaching traffic.

Figure 11 illustrates that for left turns the sighting angle is restricted to a maximum of 120° for a give way situation and 160°to 180° for a free flow left turn. The sighting angles are restricted to a maximum of 110° for right turns, and 170°to 180° for right-turn merges (**Figure 12**).

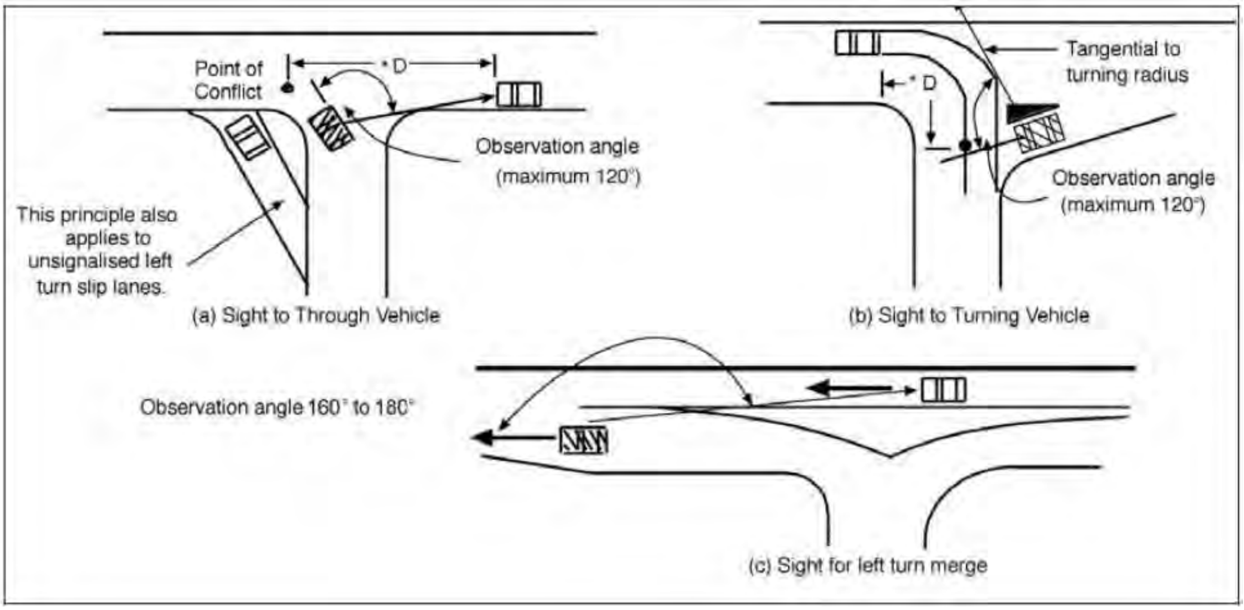


Figure 11 - *MGSD* requirements and angles for traffic turning left

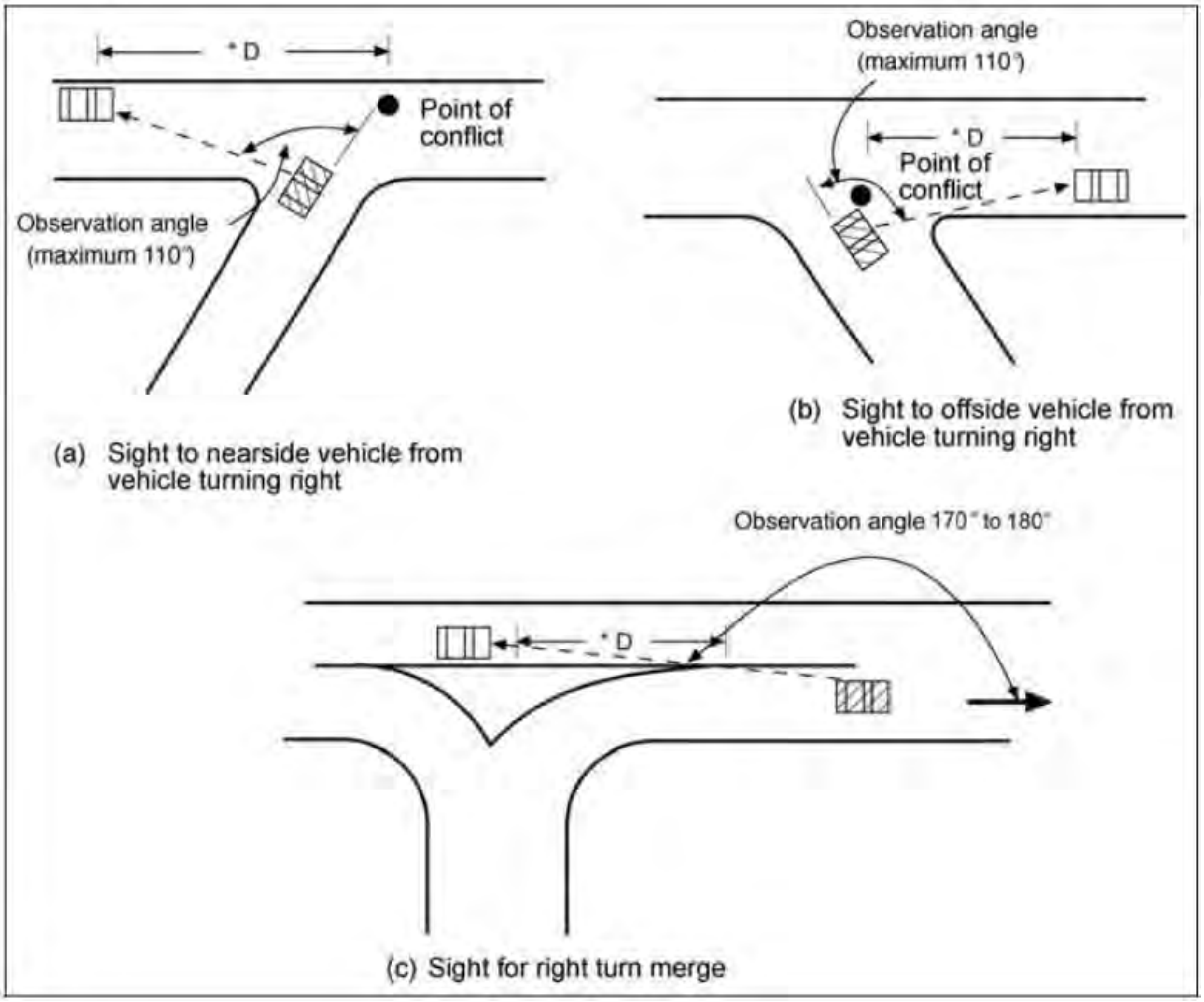


Figure 12 - *MGSD* requirements and angles for traffic turning right

Based on the tables 3.4 and 3.5 of *AGRD4A*, the assessed 'D' for *MSGD* at the abattoir access road/ Stuart Highway intersection is **305 m** for the left turns out (sight to through vehicle) and **153 m** for the right turns out (sight to nearside vehicle). These are both less than the available sight distances and therefore are deemed satisfactory.

A final consideration with respect to the safe operation of the intersection is the presence of the rail crossing on the abattoir access road approximately 130 m from Stuart Highway. Safety of the intersection could be compromised if queues at the rail crossing extend close to Stuart Highway. This is discussed and assessed in detail in **Section 4**.

4. RAIL CROSSING

There is a passive STOP controlled single track rail crossing on the abattoir access road of the Darwin-Adelaide rail line approximately 130 m from Stuart Highway. The rail track is curved at this location and the existing crossing angle is skewed at approximately 130°, as shown in the layout at **Figure 13**.

Figure 13 – Schematic layout of rail crossing of abattoir access road

At-grade railway level crossings present a potential for severe crashes. Designers should aim to eliminate, improve, or grade separate existing crossings and to avoid the introduction of any new at-grade crossings where possible.

This section outlines geometric guidelines for typical situations that arise for at-grade railway/ road level crossings.

It is important to note that the initial assessment is based on the existing layout and rail crossing. This allows for an understanding of the current situation and to quantify any benefit in the proposed re-alignment of the access road and repositioned rail crossing. **Section 4.4** contains a comparison of the assessment carried out for both arrangements and discusses the benefits or otherwise in more detail.

4.1 SIGHT DISTANCE (EXISTING LAYOUT)

The sight distance requirements for a railway level crossing depend on the form of control. The forms of control are:

- passive control by give-way signs
- passive control by stop signs
- active control (flashing lights, boom barriers, etc.).

For passive control by stop sign (as per the abattoir access road crossing) sufficient sight distance should be available for a road vehicle driver at the railway crossing stop line to be able to start off and clear the crossing before the arrival of a previously unseen train. Where this sight distance cannot be achieved either the sight distance must be increased to the required value by undertaking works (e.g. sight benching in cuttings, general earthworks, clearing or geometric changes to the road approaches and crossing) or active control devices must be installed.

AS 1742.7[(2)] specifies the use of railway crossing warning signs which prompt drivers to look for trains when approaching a crossing that has passive control and to look for a flashing light assembly when approaching a crossing that has active control. The use of such signs does not diminish the need for adequate sight distance.

The derivation of sight distance requirements at this railway level crossing has been carried out in accordance with Appendix B of *AGTM04/09*[(3)] and is provided in the following pages.

The assessment is based on the approach with the worst observed sight lines, i.e. the westbound approach (exiting the abattoir site). Sight distance criteria are shown in **Figure 14** and Table 7 (page 25).

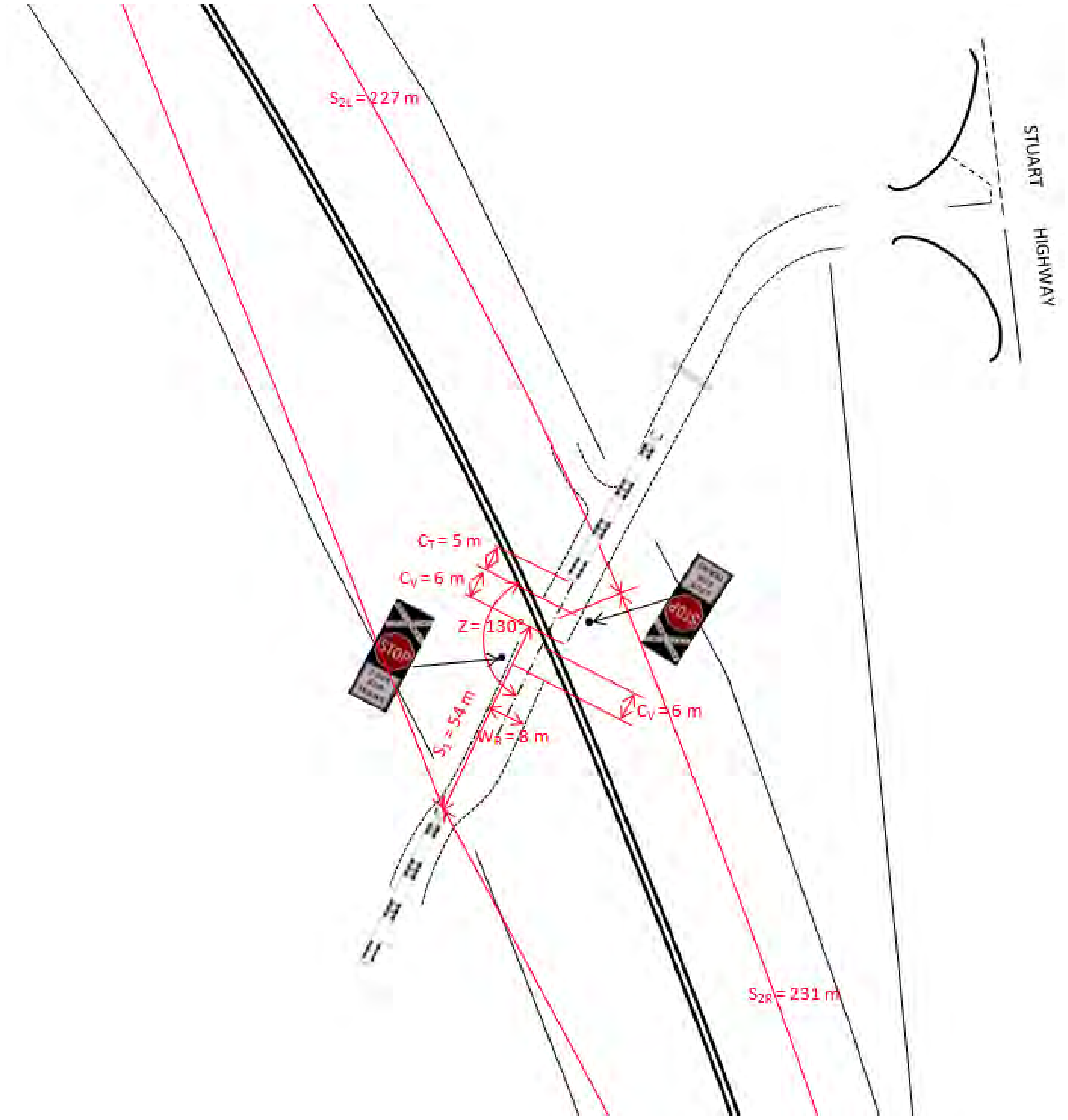


Figure 14 – Approach visibility at the existing railway level crossing (CASE 1 criteria shown)

S_1	=	minimum distance of an approaching road vehicle from the nearest rail when the driver of the vehicle can see an approaching train (m).		
S_2	=	minimum distance of an approaching train from the point of impact with a road vehicle, when the driver of the road vehicle first sees a train approaching in order to safely stop at the stop or holding line (m).		
V_T	=	the speed of the train approaching the crossing (the allowed operating speed of trains, as advised by the rail authority) (km/h).	=	105
R_T	=	perception/ reaction time (general case assumption = 2.5 s).	=	2.5
V_V	=	the 85th percentile road vehicle speed in the vicinity of the crossing. The road speed limit plus 10% is a reasonable approximation where the 85th percentile speed is not known (km/h).	=	40
F	=	coefficient of longitudinal friction (Table 8.2 Austroads Guide to Road Design Part 3: Geometric Design)	=	0.29
L_d	=	distance from the driver to the front of the vehicle (general case assumption = 1.5 m).	=	1.5
C_V	=	clearance from the vehicle stop or holding line to the nearest rail (general case assumption = 3.5 m).	=	6.0
G	=	grade, negative for downhill, positive for uphill (m/m)	=	0.00
C_T	=	clearance or safety margin from stop or holding line on departure side of the crossing (general case assumption = 5 m).	=	5.0
L	=	length of road vehicle (i.e. Design vehicle for road) (m).	=	36.5
W_R	=	width of the travelled way (portion of the roadway allocated for the movement of the vehicles) at the crossing (m).	=	8.0
W_T	=	width, outer rail to outer rail, of the rail tracks at the crossing (1.1 m for single track, 5.1 m for double track).	=	1.1
Z	=	angle between the road and the railway at the crossing (degrees).	=	130
a	=	average acceleration of the vear in starting gear (general case assumption = 0.5 m/s^2 - refer Table C2).	=	0.36
J	=	sum of the perception time and time required to depress the clutch (general case assumption = 2 s).	=	2.0

Table 7 – Sight Distance Criteria – westbound approach to existing rail crossing on abattoir access road

Sight Distance Requirements

Case 1 allows a motorist approaching the crossing at distance S_1 to sight a train at distance S_2 from the crossing and either:
Case 1(i) Decelerate and safely stop at the stop or holding line, or
Case 1(ii) Proceed and clear the crossing with an adequate safety margin

When motorists reach a crossing and see a train approaching, they must decide whether to decelerate and stop, or proceed and clear the crossing. There is a finite distance required between the vehicle and the rail in order to reach a decision and act in safety. This distance assuming a level grade crossing site, comprises four components:

- The distance travelled during the perception/ reaction time is given by Equation 1:

Equation 1

$$\frac{R_T V_V}{3.6} = \frac{100}{3.6} = \mathbf{28}\ \textbf{metres}$$

- Braking distance is given by Equation 2:

Equation 2

$$\frac{V_V^{\,2}}{2a} = \frac{\left[\dfrac{V_V}{3.6}\right]^2}{2gF} = \frac{V_V^{\,2}}{254F} = \frac{1600}{73.66} = \mathbf{22}\ \textbf{metres}$$

g = acceleration due to gravity (= 9.81 m/s^2)

Thus to stop on level ground, the required S_1 is given by Equation 3:

Equation 3

$$S_1 \geq \frac{R_T V_V}{3.6} + \frac{V_V^{\,2}}{254F} + L_d + C_V$$

$$S_1 \geq 27.8 + 21.7 + 1.5 + 6 = \mathbf{57}\ \textbf{metres}$$

Case 1(i): Decelerate and Safely Stop at the Stop or Holding Line

Equation 5
The time required for a motorist (at a distance S1 from the nearest rail) to stop at the stop or holding line, comprises:

$$\frac{V_V}{a} = \left[\frac{\frac{V_V}{3.6}}{gF} \right] = \frac{V_V}{35.3F}$$

where:

g = acceleration due to gravity (= 9.81 m/s^2)

Equation 6
Therefore, for the motorist to safely stop, the train would have to be sighted at a minimum distance, S_2 from the crossing as given by:

$$S_2 = \frac{V_T}{3.6} \left[R_T + \frac{V_V}{35.3F} \right]$$

$$S_2 = \frac{105}{3.6} \left[2.5 + \frac{40}{10.24} \right] = \textbf{187 metres}$$

Equation 7
Adjustment for S_{2L} equation

$$= \frac{0.5W_R}{\sin Z} = \frac{4.00}{-0.9301} = \textbf{-4 metres}$$

The minimum distance for a train approaching from the left of the crossing, to enable the driver of a road vehicle to decelerate and safely stop at the stop or holding line is given in Equation 8:

Equation 8

$$S_{2L(I)} \geq \frac{0.5W_R}{\sin Z} + \frac{VT}{3.6} \left[R_T + \frac{V_V}{35.3F} \right] = \textbf{183 metres}$$

The minimum distance for a train approaching from the right of the crossing, to enable the driver of a road vehicle to decelerate and safely stop at the stop or holding line is given in Equation 9:

Equation 9

$$S_{2R(I)} = \frac{V_T}{3.6} \left[R_T + \frac{V_V}{35.3F} \right] = \textbf{187 metres}$$

The calculated distances S_{2L} and S_{2R} are then compared to the distances obtained in the case of a driver of a road vehicle safely proceeding and clearing the crossing, **Case 1 (ii)**.
The larger value (i.e. the distance required to stop compared with the distance required to proceed safely through the crossing) is adopted as the critical case.

Case 1(ii): Proceed and Clear the Crossing with an Adequate Safety Margin

It is also important to consider the case in which the motorists at distance S1 from the crossing decides to proceed (even though he/ she could safely stop) and attempt to clear the crossing prior to the arrival of the train.

The distance a motorist has to travel to clear the crossing is given by Equation 10:

Equation 10

$$S_1 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + C_V + C_T + L - L_d$$

$$57 + \frac{8.0}{2.53} + \frac{1.1}{-0.93} + 6 + 5.0 + 36.5 - 1.5 = \mathbf{105} \ \textbf{metres}$$

The distance travelled by the train for the motorist to proceed and clear the crossing is given by equation 12:

Equation 12

$$S_2 = \frac{V_T}{V_V}\left[\frac{R_T V_V}{3.6} + \frac{V_V^{\,2}}{254(F+G)} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + CT + L\right]$$

$$S_2 = \frac{105}{40}\left[28 + \frac{1600}{73.66} + 3.16 + -1.18 + 53.50\right]$$

$$S_2 = 2.63 \times 105 = \mathbf{276} \ \textbf{metres}$$

Case 2: Sight Distance Required for STOP sign Control

When motorists are stationary at a crossing controlled by a STOP sign, they require adequate sight distance to determine whether or not it is safe to cross the tracks before the train arrives. Referring to Figure C2, it presents a method by which the time taken to complete this manoeuvre can be ascertained. The time comprises:

- perception time and time required to depress clutch (J)
- time to clear the crossing by a safe distance given by Equation 15.

Equation 15

$$\left[2 \left[\frac{\frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + CT + L}{a} \right]^{1/2} \right]$$

$$\left[2 \left[\frac{3.16 + -1.18 + 53.50}{0.36} \right]^{1/2} \right] = 41 \text{ seconds}$$

The distance travelled by the train during this time is given by equation 16:

Equation 16

$$S_3 = \frac{V_T}{3.6} \left[J + \left[2 \left[\frac{\frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + CT + L}{a} \right]^{1/2} \right] \right]$$

$$S_3 = \frac{105}{3.6} \left[2.0 + 41 \right] = 1{,}265 \text{ metres}$$

A sight distance adjustment is necessary to calculate S_{3L} for common datum point used in the field survey. The datum point referenced in the field survey is in the intersection of the centre line of the road and the mid-point of the railway tracks at the crossing.

Equation 18

Adjustment for S_{3L} equation

$$= \frac{0.5W_R}{\sin Z} = \frac{4.00}{-0.9301} = -4 \text{ metres}$$

Therefore, the minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of a road vehicle must first see a train approaching from the left in order to safely cross the track from a stopped position is:

1,261 metres

The minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of a road vehicle must first see a train approaching from the right in order to safely cross the track from a stopped position is:

1,265 metres

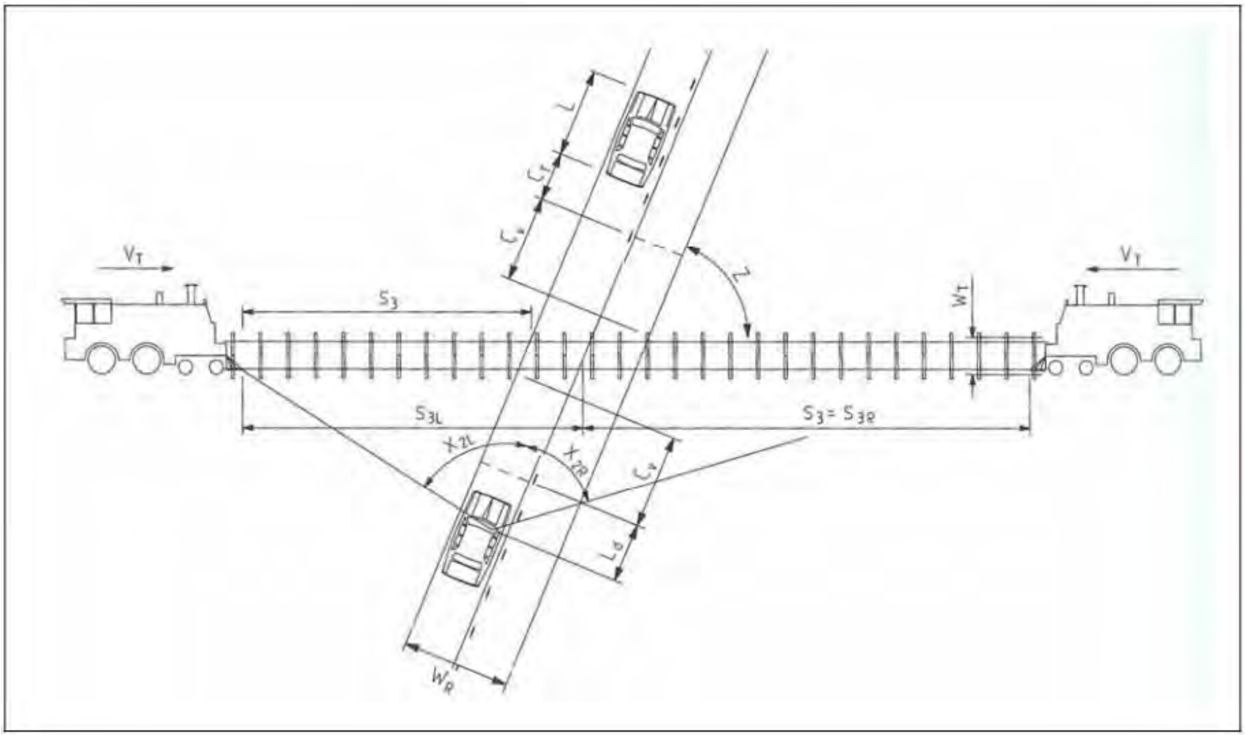


Figure C2 – Approach visibility at the railway level crossing – Case 2

4.2 SIGHT DISTANCE (PROPOSED LAYOUT)

The following calculations are based on the proposed layout and assessed sight distance criteria as shown in **Table 8** and **Figure 15** (page 32).

S_1	=	minimum distance of an approaching road vehicle from the nearest rail when the driver of the vehicle can see an approaching train (m).		
S_2	=	minimum distance of an approaching train from the point of impact with a road vehicle, when the driver of the road vehicle first sees a train approaching in order to safely stop at the stop or holding line (m).		
V_T	=	the speed of the train approaching the crossing (the allowed operating speed of trains, as advised by the rail authority) (km/h).	=	105
R_T	=	perception/ reaction time (general case assumption = 2.5 s).	=	2.5
V_V	=	the 85th percentile road vehicle speed in the vicinity of the crossing. The road speed limit plus 10% is a reasonable approximation where the 85th percentile speed is not known (km/h).	=	60
F	=	coefficient of longitudinal friction (Table 8.2 Austroads Guide to Road Design Part 3: Geometric Design)	=	0.29
L_d	=	distance from the driver to the front of the vehicle (general case assumption = 1.5 m).	=	1.5
C_V	=	clearance from the vehicle stop or holding line to the nearest rail (general case assumption = 3.5 m).	=	3.5
G	=	grade, negative for downhill, positive for uphill (m/m)	=	0.00
C_T	=	clearance or safety margin from stop or holding line on departure side of the crossing (general case assumption = 5 m).	=	5.0
L	=	length of road vehicle (i.e. Design vehicle for road) (m).	=	36.5
W_R	=	width of the travelled way (portion of the roadway allocated for the movement of the vehicles) at the crossing (m).	=	8.0
W_T	=	width, outer rail to outer rail, of the rail tracks at the crossing (1.1 m for single track, 5.1 m for double track).	=	1.1
Z	=	angle between the road and the railway at the crossing (degrees).	=	90
a	=	average acceleration of the vear in starting gear (general case assumption = 0.5 m/s^2 - refer Table C2).	=	0.36
J	=	sum of the perception time and time required to depress the clutch (general case assumption = 2 s).	=	2.0

Table 8 – Sight Distance Criteria – westbound approach to proposed rail crossing on realigned abattoir access road

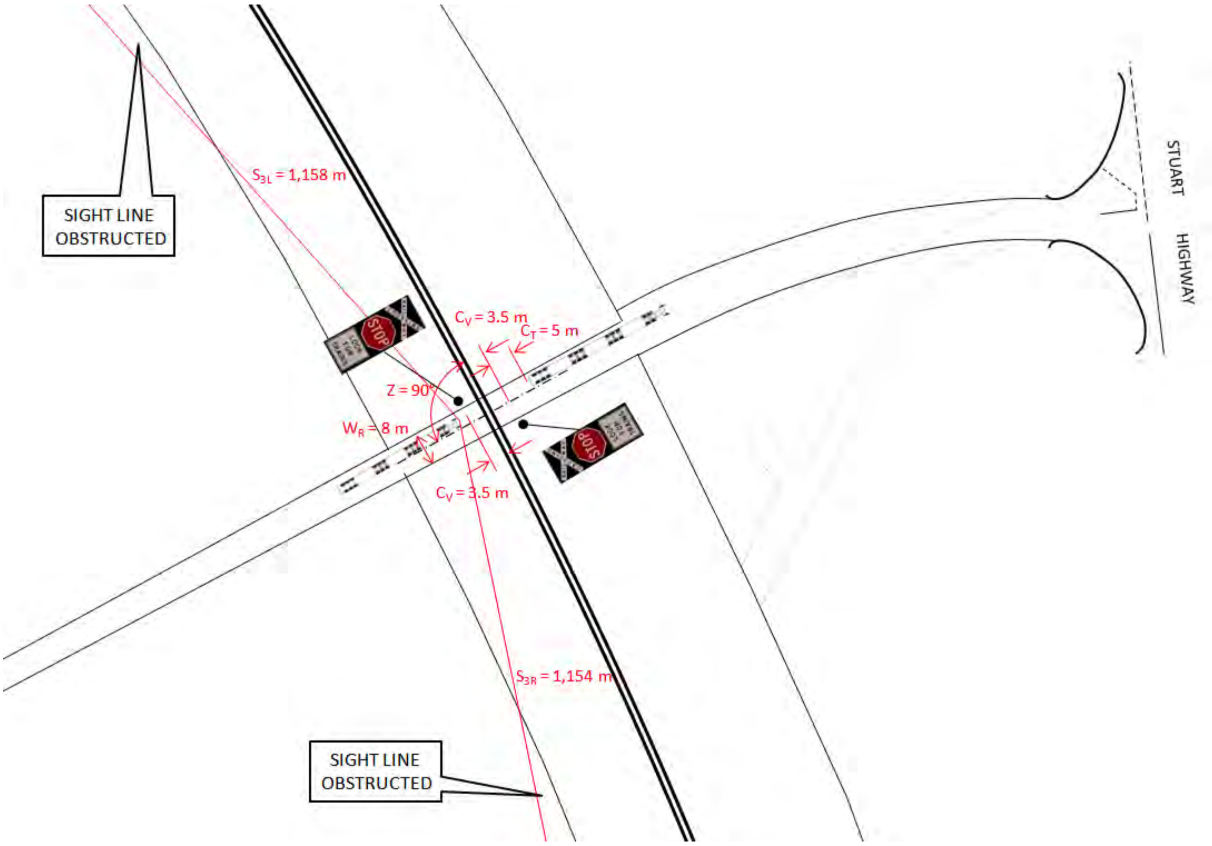


Figure 15 – Approach visibility at proposed railway level crossing (CASE 2 criteria shown)

Sight Distance Requirements

Case 1 allows a motorist approaching the crossing at distance S_1 to sight a train at distance S_2 from the crossing and either:

Case 1(i) Decelerate and safely stop at the stop or holding line, or

Case 1(ii) Proceed and clear the crossing with an adequate safety margin

When motorists reach a crossing and see a train approaching, they must decide whether to decelerate and stop, or proceed and clear the crossing. There is a finite distance required between the vehicle and the rail in order to reach a decision and act in safety. This distance assuming a level grade crossing site, comprises four components:

- The distance travelled during the perception/ reaction time is given by Equation 1:

Equation 1

$$\frac{R_T V_V}{3.6} = \frac{150}{3.6} = \mathbf{42} \quad \textbf{metres}$$

- Braking distance is given by Equation 2:

Equation 2

$$\frac{V_V^{\,2}}{2a} = \frac{\left[\frac{V_V}{3.6}\right]^2}{2gF} = \frac{V_V^{\,2}}{254F} = \frac{3600}{73.66} = \mathbf{49} \quad \textbf{metres}$$

g = acceleration due to gravity (= 9.81 m/s^2)

Thus to stop on level ground, the required S_1 is given by Equation 3:

Equation 3

$$S_1 \geq \frac{R_T V_V}{3.6} + \frac{V_V^{\,2}}{254F} + L_d + C_V$$

$$S_1 \geq 41.7 + 48.9 + 1.5 + 3.5 = \mathbf{96} \quad \textbf{metres}$$

Case 1(i): Decelerate and Safely Stop at the Stop or Holding Line

Equation 5
The time required for a motorist (at a distance S1 from the nearest rail) to stop at the stop or holding line, comprises:

$$\frac{V_V}{a} = \frac{\left[\frac{V_V}{3.6}\right]}{gF} = \frac{V_V}{35.3F}$$

where:

g = acceleration due to gravity (= 9.81 m/s^2)

Equation 6
Therefore, for the motorist to safely stop, the train would have to be sighted at a minimum distance, S_2 from the crossing as given by:

$$S_2 = \frac{V_T}{3.6}\left[R_T + \frac{V_V}{35.3F}\right]$$

$$S_2 = \frac{105}{3.6}\left[2.5 + \frac{60}{10.24}\right] = \mathbf{244} \quad \textbf{metres}$$

Equation 7
Adjustment for S_{2L} equation

$$= \frac{0.5W_R}{\sin Z} = \frac{4.00}{0.894} = \mathbf{4} \quad \textbf{metres}$$

The minimum distance for a train approaching from the left of the crossing, to enable the driver of a road vehicle to decelerate and safely stop at the stop or holding line is given in Equation 8:

Equation 8

$$S_{2L(I)} \geq \frac{0.5W_R}{\sin Z} + \frac{VT}{3.6}\left[R_T + \frac{V_V}{35.3F}\right] = \mathbf{248} \quad \textbf{metres}$$

The minimum distance for a train approaching from the right of the crossing, to enable the driver of a road vehicle to decelerate and safely stop at the stop or holding line is given in Equation 9:

Equation 9

$$S_{2R(I)} = \frac{V_T}{3.6}\left[R_T + \frac{V_V}{35.3F}\right] = \mathbf{244} \quad \textbf{metres}$$

The calculated distances S_{2L} and S_{2R} are then compared to the distances obtained in the case of a driver of a road vehicle safely proceeding and clearing the crossing, **Case 1 (ii)**.
The larger value (i.e. the distance required to stop compared with the distance required to proceed safely through the crossing) is adopted as the critical case.

Case 1(ii): Proceed and Clear the Crossing with an Adequate Safety Margin

It is also important to consider the case in which the motorists at distance S1 from the crossing decides to proceed (even though he/ she could safely stop) and attempt to clear the crossing prior to the arrival of the train.

The distance a motorist has to travel to clear the crossing is given by Equation 10:

Equation 10

$$S_1 + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + C_V + C_T + L - L_d$$

$$96 + \frac{8.0}{-2.00} + \frac{1.1}{0.89} + 3.5 + 5.0 + 36.5 - 1.5 = \mathbf{136} \quad \textbf{metres}$$

The distance travelled by the train for the motorist to proceed and clear the crossing is given by equation 12:

Equation 12

$$S_2 = \frac{V_T}{V_V}\left[\frac{R_T V_V}{3.6} + \frac{V_V^{\,2}}{254(F+G)} + \frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + CT + L\right]$$

$$S_2 = \frac{105}{60}\left[42 + \frac{3600}{73.66} + -4.01 + 1.23 + 48.50\right]$$

$$S_2 = 1.75 \times 136 = \mathbf{238} \quad \textbf{metres}$$

Case 2: Sight Distance Required for STOP sign Control

When motorists are stationary at a crossing controlled by a STOP sign, they require adequate sight distance to determine whether or not it is safe to cross the tracks before the train arrives. Referring to Figure C2, it presents a method by which the time taken to complete this manoeuvre can be ascertained. The time comprises:

- perception time and time required to depress clutch (J)
- time to clear the crossing by a safe distance given by Equation 15.

Equation 15

$$\left[2 \left[\frac{\frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + CT + L}{a} \right]^{1/2} \right]$$

$$\left[2 \left[\frac{-4.01 + 1.23 + 48.50}{0.36} \right]^{1/2} \right] = \mathbf{38} \quad \textbf{seconds}$$

The distance travelled by the train during this time is given by equation 16:

Equation 16

$$S_3 = \frac{V_T}{3.6} \left[J + \left[2 \left[\frac{\frac{W_R}{\tan Z} + \frac{W_T}{\sin Z} + 2C_V + CT + L}{a} \right]^{1/2} \right] \right]$$

$$S_3 = \frac{105}{3.6} \left[2.0 + 38 \right] = \mathbf{1{,}154} \quad \textbf{metres}$$

A sight distance adjustment is necessary to calculate S_{3L} for common datum point used in the field survey. The datum point referenced in the field survey is in the intersection of the centre line of the road and the mid-point of the railway tracks at the crossing.

Equation 18

Adjustment for S_{3L} equation

$$= \frac{0.5W_R}{\sin Z} = \frac{4.00}{0.894} = \mathbf{4} \quad \textbf{metres}$$

Therefore, the minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of a road vehicle must first see a train approaching from the left in order to safely cross the track from a stopped position is:

1,158 metres

The minimum distance of an approaching train from the intersection of the road centre line and the mid point of the rail tracks, when the driver of a road vehicle must first see a train approaching from the right in order to safely cross the track from a stopped position is:

1,154 metres

4.3 RAIL CROSSING COMPARISON

An overall comparison of the calculated sight distance criteria for the existing and proposed rail crossing and realigned access road (with associated increase in approach and crossing speeds from 40 km/h to 60 km/h) is shown in **Table 9**.

	Case 1 (i)				Case 1 (ii)		Case 2		
	S_1	S_2	S_{2L}	S_{2R}	S_1	S_2	S3	S_{3L}	S_{3R}
Existing	≥ 57 m	187 m	183 m	187 m	105 m	276 m	1,265 m	1,261 m	1,265 m
Proposed	≥ 96 m	244 m	248 m	244 m	136 m	238 m	1,154 m	1,158 m	1,154 m

Table 9 – Comparison of sight distance criteria for existing and proposed rail crossing

More specific details and assessment is provided in the following sections.

4.3.1 Sight Triangles

Sight triangles are required at railway level crossings that have passive control. The relationship between the sight distance triangles for the give-way sign and the stop sign is shown in **Figure 16**.

Triangle A represents the sight distance required for a road vehicle approaching and potentially passing through the level crossing at speed (i.e. give-way sign control can be used). Triangle B represents the sight distance required for safe start up and clearance from the crossing for a stopped vehicle (i.e. the triangle needed for both stop and give-way sign control).

Whilst the sight distances in triangle B are met with both the existing and proposed layout (subject to minor clearance), the sight distances for triangle A are not for either (Refer Equation 18 in the respective calculation pages).

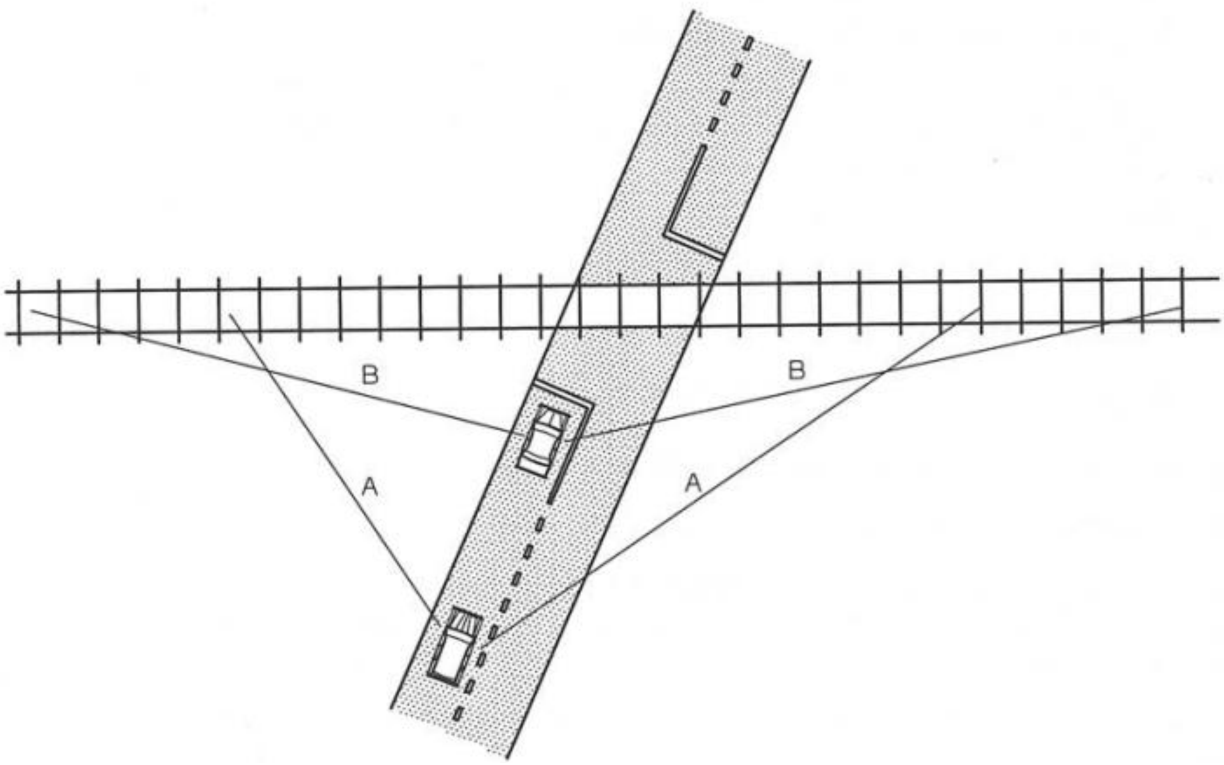


Figure 16 - Sight triangles for give way and stop sign control (Source AS 1742.7)

4.3.2 Angle of Approach

The most desirable angle of crossing is a right angle as this will usually produce the best sight distance for both road and rail vehicles and enable designers to achieve the most satisfactory grading of the road where it crosses the rails. However, where a skewed crossing cannot be avoided the angles shown in Figure 10.3 should not be exceeded (i.e. not greater than 110° to the left or 140° to the right).

A skewed crossing may be required where the crossing is the result of a road parallel to the railway changing from one side to the other using reverse horizontal curves to effect the change. In addition to limiting the angle of skew:

- it is necessary to ensure that the curve radii are suitable for the speed environment of the crossing it may be essential to change the approach geometry of the road
- it is important to introduce speed reducing devices at the crossing to avoid crashes resulting from loss of control of vehicles on curves comprising a large decrease in speed.

Designers should be aware that it is unknown whether any safety benefit would result from the provision of sharp horizontal curves on the approaches to railway level crossings. Where the road traffic volume is high but there is little rail traffic, the sharp curves may lead to single vehicle out of-control crashes and a higher total crash rate than would be the case with a higher speed road alignment.

The existing angle of approach is 130°, which is less than the maximum of 140°. The proposed angle of approach is 90°, which is ideal.

4.3.3 Horizontal Alignment

Approach and crossing visibility is the primary feature affecting safety of the at-grade railway level crossings. The approach visibility is deemed to be adequate when an area of unrestricted visibility exists for each approach as shown in **Figure 16**.

Approach visibility is adequate when the following conditions are met:

> The driver of an approaching vehicle, travelling at the 85th percentile speed (V_V) can see a train travelling at maximum operating speed (V_T), when the vehicle and the train are at distances S_1 and S_2 respectively from the crossing, such that the vehicle can either safely stop short of the crossing, or clear the crossing before the train reaches it. Appropriate values of V_T should be obtained from the rail authority.

Distance S_1 must not be less than truck stopping sight distance. For a given vehicle, the approach visibility must be adequate for trains approaching from either direction.

The approach visibility angle must not exceed 95° to the left of the crossing and 110° to the right of the crossing as shown in **Figure 17**. Occasional obstructions such as posts, small trees and sparse vegetation can be considered acceptable if their size and spacing would not obscure the driver's vision of a train.

Crossing visibility is deemed to be adequate when an area of unrestricted visibility exists for each approach and the driver of a stationary vehicle, positioned at a stop line, has a clear view of approaching trains to a distance along the tracks such that a train appearing in the driver's field of view (at the point where the vehicle begins to move) would reach the crossing after the vehicle has cleared the crossing.

For the purpose of calculating the visibility triangle, the following figures should be used:

- distance from the driver's eye to the rail, while at a standstill, is 5.0 m
- height of the driver's eye above the road is 1.1 m
- height of train above the rails is 2.3 m.

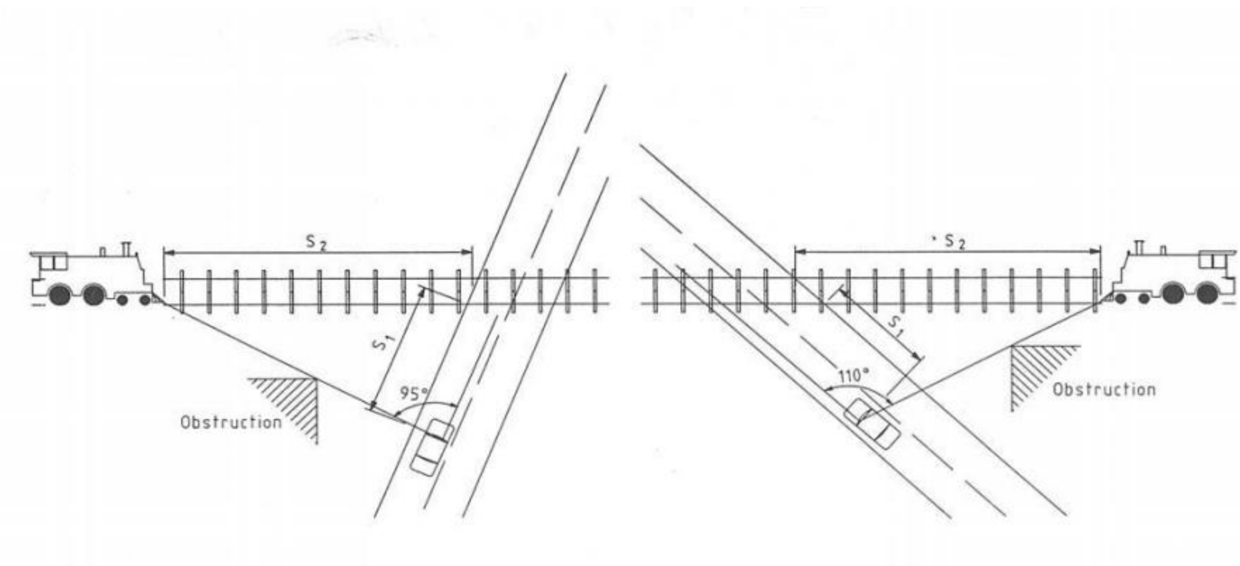
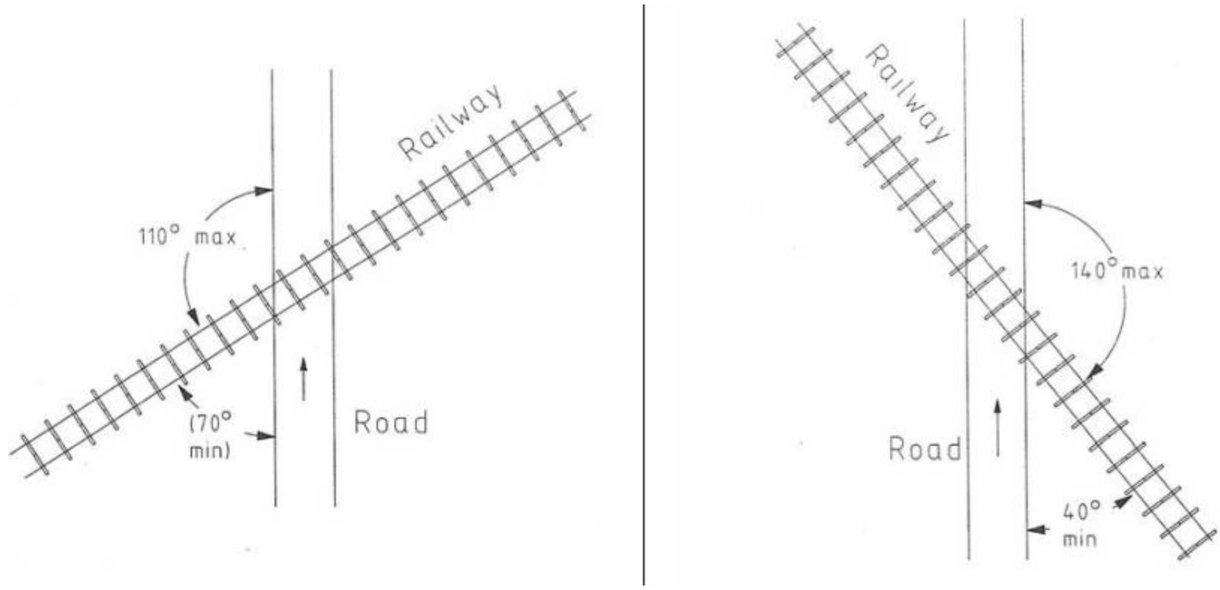


Figure 17 – Approach Visibility Angles (Source Figure 10.1 AGTM04/09)



(a) for driver looking left (b) for driver looking right

Figure 18 – Crossing visibility angle for drivers looking left and right (Source Figure 10.3 AFTM04/09)

For a given vehicle, the crossing visibility must be adequate for trains approaching from either direction. The crossing visibility angle must not exceed 110° to the left of the crossing (**Figure 18(a)**) and 140° to the right of the crossing (**Figure 18(b)**). If there is a choice of crossing angle, 90° is preferred. The crossing visibility angle is not met for either the existing or proposed arrangements.

4.4 TRAIN CROSSING DISRUPTION

An assessment of the maximum number of vehicles likely to arrive during a train crossing occurrence has indicated that there is sufficient room on each approach to accommodate 3 cars (as shown in Table 10). There is also sufficient room between Stuart Highway and the rail crossing STOP sign to accommodate 3 queued 36.5 m triple road trains; however it is very unlikely that this number of road trains will arrive at the rail crossing at the same time. The proposal to provide an additional 'escape area' for a triple road train between the rail crossing and Stuart Highway is deemed to be an appropriate risk mitigation strategy as there is always a risk, although rare, that several events will occur at one time that lead to an incident (e.g. a road train breaks down during a busy vehicular access and train crossing period).

	Per week	Per day	Per hour	Max in 1 hour
Trains	38	5.428571	0.22619	1
Intermodal freight	*12*			
Interstate passenger	*4*			
Ore	*22*			
Train speed	105	km/h		
Distance travelled from first sighting to crossing	*1,265*	m		
Max length of train	*1,800*	m		
Time taken from first sighting to clearing	*105*	seconds		
Vehicle arrivals (peak hour)	96			
Vehicle arrivals per second	*0.026667*			
Vehicle arrivals during train crossing time	*3*			

Table 10 – Assessment of rail crossing disruption

5. FINDINGS

The existing road intersection has been assessed as having spare capacity to safely accommodate the expected increased traffic.

All of the required sight distances at the existing road intersection are met or exceeded.

There are some obstructions to the required sight lines for the approach to the railway crossing but these may be able to be addressed through relocating the existing STOP signs closer to the rail and clearing areas on both sides of the rail corridor.

A significant deficiency is the lack of adequate sight lines for the assessed vehicle (fully laden road train) to commence a crossing from being stationary at the STOP sign and complete the crossing movement safely for both the existing and proposed rail crossing layouts. The sight line distances required are in excess of 1 km and the existing and proposed sight line availability is approximately 400-500 m (this was not able to be measured on site due to railway corridor access restrictions).

The assessment has revealed that any kind of passive control is not an appropriate form of control for the proposed crossing (or the existing crossing with the additional traffic) and that active control (flashing lights, boom barriers, etc.) must be perused, subject to a much more detailed assessment using the Australian Level Crossing Assessment Model (ALCAM).

The assessment has also found that the proposed re-aligned access road, railway and rail crossing offer safety advantages over the existing layout.

Details regarding active control are contained within Australian Standard *AS 1742.7*(2).

Details regarding ALCAM can be found at the NSW Transport website at http://www.transport.nsw.gov.au/levelcrossings/alcam.htm.

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APPENDIX A DEVELOPMENT DRAWING

APPENDIX B SIDRA INTERSECTION REPORTS

MOVEMENT SUMMARY — Site: Light & Heavy Vehicle 2009

Stuart Highway/ Abattoir Access Road, Livingstone. Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: STUART HWY											
1	L	1	0.0	0.001	25.0	LOS D	0.0	0.0	0.00	0.86	70.0
2	T	115	22.0	0.067	0.0	LOS A	0.0	0.0	0.00	0.00	110.0
Approach		116	21.8	0.067	0.2	NA	0.0	0.0	0.00	0.01	109.6
North: STUART HWY											
3	T	113	22.0	0.066	0.0	LOS A	0.0	0.0	0.00	0.00	110.0
4	R	1	0.0	0.001	26.3	LOS D	0.0	0.0	0.29	0.73	67.2
Approach		114	21.8	0.066	0.2	NA	0.0	0.0	0.00	0.01	109.6
West: Abattoir Access											
5	L	1	0.0	0.001	4.2	LOS A	0.0	0.0	0.27	0.43	47.0
6	R	1	0.0	0.001	4.2	LOS A	0.0	0.0	0.27	0.45	47.0
Approach		2	0.0	0.001	4.2	LOS A	0.0	0.0	0.27	0.44	47.0
All Vehicles		232	21.6	0.067	0.3	NA	0.0	0.0	0.00	0.01	108.9

MOVEMENT SUMMARY — Site: Light Vehicle 2015

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: STUART HWY											
1	L	11	0.0	0.006	25.0	LOS D	0.0	0.0	0.00	0.86	70.0
2	T	128	22.0	0.075	0.0	LOS A	0.0	0.0	0.00	0.00	110.0
Approach		139	20.3	0.075	1.9	NA	0.0	0.0	0.00	0.07	107.0
North: STUART HWY											
3	T	126	22.0	0.074	0.0	LOS A	0.0	0.0	0.00	0.00	110.0
4	R	92	0.0	0.137	27.3	LOS D	0.6	3.9	0.40	0.81	64.8
Approach		218	12.8	0.137	11.5	NA	0.6	3.9	0.17	0.34	90.4
West: Abattoir Access											
5	L	92	0.0	0.066	4.2	LOS A	0.3	2.1	0.27	0.47	47.0
6	R	11	0.0	0.066	4.2	LOS A	0.3	2.1	0.27	0.53	47.0
Approach		102	0.0	0.066	4.2	LOS A	0.3	2.1	0.27	0.48	47.0
All Vehicles		459	12.2	0.137	7.0	NA	0.6	3.9	0.14	0.29	83.5

MOVEMENT SUMMARY — Site: Heavy Vehicle 2015

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: STUART HWY											
1	L	1	21.0	0.001	26.9	LOS D	0.0	0.0	0.00	0.86	70.0
2	T	128	22.0	0.075	0.0	LOS A	0.0	0.0	0.00	0.00	110.0
Approach		129	22.0	0.075	0.2	NA	0.0	0.0	0.00	0.01	109.7
North: STUART HWY											
3	T	126	22.0	0.074	0.0	LOS A	0.0	0.0	0.00	0.00	110.0
4	R	14	21.0	0.023	29.0	LOS D	0.1	0.7	0.35	0.77	65.3
Approach		140	21.9	0.074	2.8	NA	0.1	0.7	0.03	0.07	105.5
West: Abattoir Access											
5	L	14	21.0	0.011	4.8	LOS A	0.0	0.4	0.28	0.46	46.9
6	R	1	21.0	0.011	4.8	LOS A	0.0	0.4	0.28	0.50	46.9
Approach		15	21.0	0.011	4.8	LOS A	0.0	0.4	0.28	0.47	46.9
All Vehicles		284	21.9	0.075	1.7	NA	0.1	0.7	0.03	0.06	103.5