Chapter 5 Full procedures for project evaluation

5.1 Overview

Introduction

This chapter describes the procedures and provides worksheets for full economic efficiency evaluation of land transport projects submitted to Land Transport NZ for funding.

In this chapter

This chapter contains the following topics:

5.2 Application of full procedures

Relationship to project type requirements and simplified procedures

The full procedures are to used for economic efficiency evaluation when either more detailed analysis is required than is provided in the simplified procedures, or the limits specified for the simplified procedures are exceeded.

The full procedures may be used for all types of land transport projects with appropriate adaptation. The benefits and costs considered in the evaluation should be adjusted or added to as appropriate to the project type.

The evaluation must comply with the requirements for the particular type of project as follows:

Project type	Reference
Road project	Volume 1, chapter 3
Transport demand management	Volume 2, chapter 3
Transport services	Volume 2, chapter 5
Walking and cycling	Volume 2, chapter 8
Education, promotion and marketing	Volume 2, chapter 9
Parking and land use	Volume 2, chapter 10
Private sector financing and road tolling	Volume 2, chapter 11

Worksheets

The full procedures consist of a series of worksheets to guide the calculation and encourage consistency of presentation. These worksheets are used as far as is practical when preparing evaluations. Non-standard worksheets may be submitted with evaluation reports provided the necessary information can be readily gleaned from such worksheets and is referenced on the project checklist.

The worksheets provided in this manual are designed to allow some flexibility in methods of calculation since no two project evaluations are exactly the same.

All project evaluation reports shall contain an executive summary which is made up of worksheets 1 to 8 (WS 1 to WS 8) inclusive. Worksheets A1 to A13 are provided to assist with the calculations reported in WS 1 to WS 8.

Much of the information required for WS 1 to WS 8 contributes to other components of Land Transport NZ's funding allocation process. The expectation is that the data entered on these worksheets can be transferred to the 'Land transport programmes online' system (LTP online) and vice versa as appropriate.

Blank worksheets

Within chapter 5, some worksheets have been completed as an example. The remainder have been left blank. For convenience, appendix A14 contains a complete set of worksheets WS 1 to WS 8 and WS A1 to WS A13.

5.3 Stages of analysis

Introduction

The stages of the full economic evaluation are outlined in the table below. The final stages of the economic evaluation involve a check on the quality and completeness of the evaluation and completion of the project summary. The worksheets relevant to each stage are shown.

Stages

Stage	Description	See
1	Where appropriate, complete a project feasibility report.	PFR
2	Describe the do minimum, alternatives and options and consider packages.	WS 1
3	Assemble basic information on route, traffic, demand estimates, travel impacts, etc as appropriate.	WS A2
4	Undertake transport model checks as required.	WS 8
5	Where appropriate, calculate travel times for the do minimum and options.	WS A3
6	Quantify and calculate the appropriate monetised project benefits and disbenefits for the do minimum and options, including: • travel time cost savings, including disbenefits during construction, if appropriate (WS A4) • vehicle operating cost savings (WS A5) • accident cost savings (WS A6) • vehicle passing lane benefits (WS A7) • monetised external impacts (WS A8) • vehicle emissions (WS A9) • national strategic factors (WS A10)	WS A4 to WS A10
7	Describe and quantify where possible any significant non-monetised external impacts.	WS A8
8	Estimate the appropriate project costs	WS 2
9	Summarise the benefits and costs of do minimum and project options, including their: • type • timing • estimated value • year in which estimate was made • growth rate over project evaluation period	WS 2
10	Describe and evaluate the benefits and costs of mitigation measures for external impacts	WS A8.2

5.3 Stages of analysis, continued

Stages, continued

Stage	Description	See
11	If appropriate, describe business benefits and equity impacts (particularly those relating to transport disadvantaged).	
12	Discount the benefits, disbenefits and costs for the do minimum and project options over the period of analysis and sum them to obtain the total present value (PV) of benefits and costs. Apply update factors as necessary.	WS A1
13	List the PV of benefits and costs for the do minimum and each option, calculate the benefit and cost differentials for each option (compared to the do minimum) and calculate the national benefit cost ratio and the government benefit cost ratio (if appropriate) for all options.	WS 3
14	Where there is more than one mutually exclusive option (including different mitigation measures), use incremental analysis to select the preferred option.	WS 4
15	Calculate the first year rate of return for the preferred project option.	WS 5
16	Conduct a sensitivity analysis on the uncertain elements of the preferred project option.	WS 6
17	Where the project costs are greater than $4 million for infrastructure activities or $1 million for travel demand management, rail and sea freight activities or there are other unpredictable events that may affect the project, undertake a risk analysis	WS A13
18	Complete the project evaluation checklist to verify completeness of information, accuracy of calculations and validity of assumptions.	WS 7
19	Complete the project evaluation summary, including the project description (which is the same as LTP online); road and traffic data; travel times, etc PV of benefits and costs; BCR and FYRR for the do minimum and preferred option	WS 1

5.4 Project feasibility report

Introduction

The project feasibility report (PFR) is provided as a shortened form of appraisal to decide initially if a project is worth pursuing, and if so, to assist in pre-selection of project options before carrying out more detailed appraisal.

The PFR is not intended as a complete evaluation procedure in itself but rather as a quick evaluation method before proceeding to a full evaluation.

In the context of the funding allocation process, the PFR is used in conjunction with project development as follows:

- identifying projects for the National Land Transport Programme – a PFR is submitted with the rough order of cost estimate.
- investigation activities (work categories 311, 411 and 412)
- property purchase (work categories 331, 332 and 333).

There are certain types of project for which the PFR will not be applicable, ie, traffic signalisation, intersection analysis, passing lanes, etc. In such cases, the simplified procedures in chapter 4 of this manual or another similar assessment process could be used. In a few instances, it may be necessary to use the full procedures contained in this chapter.

PFR

The PFR is comprised of two worksheets, one which provides a summary of the proposed project and completes a simple economic evaluation and the other which provides a simplified accident analysis.

PFR: Project feasibility report

Explanation sheet for preliminary evaluation **PFR**

For this preliminary evaluation, the PFR assumes that project costs are incurred in time zero (and therefore are not discounted); maintenance cost savings occur in years 2 to 25, and benefits occur in years 2 to 27. Growth rates are assumed to be 2% per annum across the board.

1. Project description: Provide a general description of the project, including the do minimum and project options. Apart from the details about the evaluator(s) and checker(s), the information required corresponds directly with the information entered in LTP online.
2. Summarise the inputs to the analysis, including do minimum and option costs, route length, average roughness, average vehicle speed, and AADT. Default values for travel time costs, base vehicle operating costs and roughness costs are provided in Tables 1, 2, and 3 respectively.
3. Calculate the potential project benefits and maintenance cost savings, using the formulae provided in the worksheet.
4. Determine the PV total benefits using the formula provided and calculate the provisional BCR.

Table 1 Travel time costs (TT) for standard traffic mixes in $/h (July 2002)

Road type	Description	$/h
Urban arterial	Arterial and collector roads within urban areas carrying traffic volumes greater than 7,000 vehicles/day	16.27
Urban other	Other urban roads carrying less than 7,000 vehicles/day	16.23
Rural strategic	Arterial and collector roads connecting main centres of population and carrying traffic of over 2,500 vehicles per day	23.25
Rural other	Rural roads other than rural strategic	22.72

Table 2 Base vehicle operating costs (CB) in cents/km (July 2002)

Average speed	30-50km/h	>50-70km/h	>70-90km/h	>90km/h
CB (cents/km)	20.4	19.9	20.6	21.6

Table 3 Roughness costs (CR) in cents/km (July 2002)

IRI (m/km)	NAASRA (counts/ km)	CR urban (cents/ km)	CR rural (cents/ km)	IRI (m/km)	NAASRA (counts/ km)	CR urban (cents/ km)	CR rural (cents/ km)
2.5	66	0.0	0.0	6.0	158	5.9	11.4
3.0	79	0.2	0.1	6.5	172	7.5	13.8
3.5	92	0.4	0.7	7.0	185	9.2	16.1
4.0	106	1.0	2.2	7.5	198	10.9	18.5
4.5	119	1.8	4.3	8.0	211	12.6	19.4
5.0	132	3.0	6.7	8.5	224	14.3	20.0
5.5	145	4.3	9.1	9.0	238	15.9	20.7

PFR: Project feasibility report, continued

Preliminary evaluation **PFR**

1 Evaluator(s) _____

Reviewer(s) _____

Approved organisation name _____

Project/package name _____

Your reference _____

Project description _____

Describe the problem to be addressed _____

Brief description of location _____

_____

Describe the do minimum _____

_____

Summarise the options assessed _____

_____

2 Time zero (assumed construction start date) 1 July

Expected duration of construction (months) _____

Date economic evaluation completed (mm/yyyy) _____

Base date for costs and benefits 1 July

Road type (circle one) urban arterial/urban other/rural strategic/rural other

Travel time cost (**TT**) – from table 1 _____ $/h Posted speed limit _____ km/h

AADT at time zero _____ veh/day

Variable	**Do minimum (M)**		**Option (P)**		
PV cost	**A**		**B**		
Length	**LM**		**LP**		km
Mean vehicle speed	**MSM**		**MSP**		km/h
Base cost (CB) – from Table 2	**CBM**		**CBP**		¢/km
Average roughness (IRI or NAASRA counts)					
Roughness cost (CR) – from Table 3	**CRM**		**CRP**		¢/km
Average vehicle speed (VS)	**VSM**		**VSP**		km/h
Annual maintenance costs (MC)	**MCM**		**MCP**		$/yr

3 **Calculations**

VOC savings = {[**LM** × (**CBM** + **CRM**)] - [**LP** × (**CBP** + **CRP**)]} × **AADT** × 3.6 = $ _____ **C**

Travel time savings = (**LM** / **VSM** - **LP** / **VSP**) × **AADT** × **TT** × 365 = $ _____ **D**

Comfort benefits from sealing = **LM** × 0.10 × **AADT** × 365 = $ _____ **E**

PV accident cost savings (from PFR accident cost savings worksheet) = $ _____ **F**

Maintenance cost savings = (**MCM** - **MCP**) × 8.6 = $ _____ **G**

4 Benefits = (**C** + **D** + **E**) × 9.3 + **F** = _____ **Y**

Costs = **B** - **A** – **G** = _____ **Z**

Provisional BCR = **Y** / **Z** = _____

PFR: Project feasibility report, continued

Explanation sheet for accident analysis **PFR**

This worksheet is suitable only for **accident-by-accident analysis** (method A in appendix A6). There must be 5 years or more accident data for the site and the number and types of accidents must meet the specifications set out in appendix A6.1 and A6.2. If not, either the accident rate analysis or weighted accident procedure described in appendix A6.2 should be used. The annual accident cost savings determined from such an evaluation are multiplied by the appropriate discount factor and entered in the PFR preliminary evaluation as total **F**.

1. Enter number of years of typical accident rate records at **(1)** and the number of reported accidents *in the reporting period* for each of the severity categories at **(2)**.
2. Multiply the total fatal + serious accidents **(2)** by the ratios **(3)** to get the adjusted fatal and serious accidents **(4)** for the reporting period. For minor and non-injury accidents, transfer the accident numbers from **(2)**. To get the accidents *per year* **(5)**, divide **(4)** by **(1)**.
3. Multiply the accidents per year **(5)** by the underreporting factors **(6)** to get the total estimated accidents per year **(7)**.
4. Enter the accident costs for each accident severity (all movements, all vehicles) for the posted speed limit from table 4.
5. Multiply accidents per year **(7)** by **(8)** to get cost per accident per year **(9)**.
6. Add the costs for each severity in line **(9)** to get the total accident cost per year **(10)** for the do minimum.
7. Determine the forecast percentage accident reduction for each accident severity category **(11)** for the option. Determine the proportion of accidents remaining [100% minus the percentage reduction **(11)**] and record in **(12)**.
8. Calculate the predicted accidents per year **(13)** by multiplying the accidents per year of the do minimum **(7)** by the percentage of accidents remaining **(12)**.
9. Enter the accident costs **(14)** for each accident severity (all movements, all vehicles) for the posted speed limit from table 4.
10. Multiply accidents per year **(13)** by **(14)** to get cost per accident per year **(15)**.
11. Add the costs for each severity in line **(15)** to get the total accident cost per year **(16)** for the option.
12. Calculate the annual accident cost savings **(17)** by subtracting the values in **(16)** from **(10)**. Multiply the annual accident cost savings **(17)** – or the total from the accident rate or weighted accident analysis – by the discount factor from table 5 for the appropriate speed limit to determine the PV accident cost savings. Transfer this total **F** to PFR preliminary evaluation.

Table 4 Cost per reported injury accident in $ (July 2006)

Speed limit	Fatal	Serious	Minor	Non-injury
50 and 60 km/h	3,350,000	360,000	21,000	2,100
≥ 70 km/h	3,800,000	405,000	24,000	2,400

Table 5 Discount factors (DF) for different speed limits for years 2 to 25 inclusive

Traffic growth rate	50 and 60 km/h	≥ 70 km/h
2.0%	7.82	9.32

PFR: Project feasibility report, continued

Accident analysis **PFR**

	Do minimum	Severity			Non-injury
		Fatal	Serious	Minor	
1	Number of years of typical accident rate records				
2	Number of reported accidents over period	fatal + serious			
3	Fatal/serious severity adjustment	0.15	0.85	1.0	1.0
4	Number of reported accidents adjusted by severity **(2)** × **(3)**				
5	Accidents per year = **(4)**/**(1)**				
6	Under-reporting factors	1.0	2.0	3.0	10
7	Total estimated accidents per year = **(5)** x **(6)**				
8	Accident cost (table 4)				
9	Accident cost per year = **(7)** x **(8)**				
10	Total cost of accidents per year (sum of columns in row **(9)** fatal + serious + minor + non-injury) $				
	Option				
11	Percentage accident reduction				
12	Percentage of accidents 'remaining' [100 – **(11)**]				
13	Predicted accidents per year **(7)** x **(12)**				
14	Accident cost (table 4)				
15	Accident cost per year = **(13)** x **(14)**				
16	Total cost of accidents per year (sum of columns in row **(15)** fatal + serious + minor + non-injury) $				
	Annual accident cost savings = **(10)** – **(16)** $				
	PV accident cost savings = **(17)** x DF (table 5) $				**F**

Transfer PV of accident cost savings, **F** to **F** on preliminary evaluation worksheet PFR

Worksheet 1: Evaluation summary

Explanation sheet for evaluation summary **Worksheet 1.1**

1. Worksheet 1 provides a general description of the project or package, including the do minimum and the alternatives and options considered, along with a summary of the data used for the evaluation and the results of the economic efficiency evaluation.
2. The information in worksheet 1 is a subset of the information required for LTP Online.
3. Evaluator(s) and checker(s): Enter the full name and contact details of the evaluator(s) and of the checker(s).
4. Project/package details: Provide a general description of the project, including the do minimum and the project options. If the evaluation is for a package as a whole, describe the component projects.
5. Location: Information provided shall include:
   - a location/route map
   - a layout plan of the project.
6. Alternatives and options: Provide a general description of the do minimum and summarise the alternatives considered and the options assessed.
7. Timing: The expected construction start should be within the financial year
8. Economic efficiency: Enter the timeframe information, the PV cost of the do minimum, the PV total net costs of the preferred option and the PV total net benefits of the preferred option from worksheet 3. The preferred option is selected as a result of the incremental analysis in worksheet 4.
9. Enter the BCR for the preferred option from worksheet 3.
10. Enter the first year rate of return (FYRR) from worksheet 5.
11. Briefly describe any non-monetised external impacts evaluated in worksheet A8.1.
12. List any national strategic factors described in worksheet A10.

Worksheet 1: Evaluation summary, continued

Evaluation summary **Worksheet 1**

1	Evaluator(s)	
	Reviewer(s)	
2	**Project/package details**	
	Approved organisation name	
	Project/package name	
	Your reference	
	Project description	
	Describe the predominant type of problem	
3	**Location**	
	Brief description of location	
4	**Alternatives and options**	
	Describe the do minimum	
	Summarise the alternatives considered	
	Summarise the options assessed	
5	**Timing**	
	Earliest construction start date (mm/yyyy)	
	Expected construction start date (mm/yyyy)	
	Expected duration of construction (months)	
6	**Economic efficiency**	
	Date economic evaluation completed (mm/yyyy)	
	Time zero	1 July
	Base date for costs and benefits	1 July
	PV cost of do minimum	$
	PV net cost of preferred option	$
	PV net benefits of preferred option	$
7	**BCR**	
8	**FYRR**	%
9	**Non-monetised impacts**	
10	**National strategic factors**	

Worksheet 2: Summary of benefits and costs

Explanation sheet for summary of benefits and costs **Worksheet 2**

This worksheet provides a summary of the benefits and costs of the do minimum and project option(s) as estimated at the outset of the evaluation. Details are provided about their occurrence throughout the life of the do minimum and project option(s), along with projected growth rates.

1	Project do minimum or option	Please indicate whether the summary is for the do minimum or project option
2	Type of benefit or cost	Enter the type of benefit or cost being considered. Note that for the do minimum, the property, preconstruction and construction costs should be 'nil'. If this is not the case, an explanation should be provided.
3	Time	Using time zero as the start of construction and assuming a 25 year period for the life of the project, enter the start and end year of the time stream for each cost and benefit item. For single payment items write the year in the 'from' column.
4	Estimate	Enter the estimate, which will be in dollars if it is a single payment or dollars per year if it is an annual or recurring benefit or cost. Estimates are determined using worksheet A2 to A9, and A13 as indicated in worksheet 2. Default contingency values are indicated below.
5	Year of estimate	Enter the year in which the benefit or cost was estimated, if different from the base date.
6	Growth rate	If the benefit or cost stream is an arithmetic growth one, enter the appropriate growth rate. An adjusted growth rate should be used for accident benefits based on appendix A6.4.

Contingency costs

The following table of default contingency allowances provides guidance. This information is to be used when better information based on experience is not available.

Phase	Earthworks component	Other works
Project feasibility report	30%	20%
Scheme assessment	25%	15%
Design and contract estimate	20%	10%
Contract	10%	5%

Worksheet 2: Summary of benefits and costs, continued

Summary of benefits and costs **Worksheet 2**

1 Project (do minimum or option) _____

Benefit or cost component (2)	Time From (3)	Time To (3)	Reference	Estimate (4)	Year of estimate (5)	Growth rate (6)
Benefits						
Travel time cost savings			WS A2, A3 & A4			
VOC savings			WS A3 & A5			
Accident cost savings			WS A6			
Vehicle emissions reductions			WS A9			
Reduced driver frustration			Appendix A7			
Monetised external impacts (list)			WS A8			
Costs						
Investigation						
Design						
Property						
Construction/implementation (including preconstruction)						
Maintenance						
Renewal						
Operating						
External impact mitigation			WS A8.2			
Risk management			WS A13			
Project contingency costs			Explanation sheet			

Worksheet 3: Benefit cost analysis

Explanation sheet for benefit cost analysis **Worksheet 3**

This worksheet is used to summarise the present value (PV) of the actual and net benefits and costs of the do minimum and project options, as calculated in WS A1.2, and to determine the BCR of the project options. If there are more than 3 options, then more than one worksheet will be required.

For each benefit and cost of the do minimum and the option(s), the PV of the total benefits and costs is entered. The PV **net** benefits (**net** costs) of the project and options are calculated by subtracting the PV benefits (costs) of the do minimum from the PV benefits (costs) of the project option.

	PV benefits	
1 - 2	Travel time savings (TTS); vehicle operating cost (VOC) savings	Enter the PV travel time cost savings and vehicle operating cost savings for the do minimum and the project options from worksheet A1.2 (or worksheet A7.3 for passing lanes).
1 - 2	TTS and VOC: Variable matrix evaluation	When reporting results of a variable matrix evaluation, enter the PV project travel time savings plus vehicle operating cost net benefits in the net benefits columns.
3	Accident cost savings	Enter the PV accident cost savings for the do minimum and the project options from worksheet A1.2.
4	Reduced driver frustration (passing lane benefit)	Enter the PV net driver frustration savings for passing lanes from worksheet A7.3 in the net present benefits columns.
5	Vehicle emissions reduction	Enter the PV vehicle emissions for the do minimum and the project options.
6	Monetised external impacts	Enter the PV of any other valued externalities.
7	Total net benefits	Calculate the total net benefits of the do minimum and project options by summing **(1)** to **(6)** for each option.
	PV costs	
8 - 14	Property, investigation, design, construction, operating, maintenance and renewal costs	Enter the PV of the approved organisation's costs for the do minimum and the project options from worksheet A1.2.
15	External impact mitigation	Enter the PV of any mitigation cost from worksheet A1.2.
16	Project contingency costs	Enter the PV of contingency costs from worksheet A1.2.
17	Risk management costs	Enter the PV of risk management costs from worksheet A1.2.
18	PV total net costs	Calculate the PV total net costs of the do minimum and project options by summing **(8)** to **(17)**.
	Benefit cost ratios	
19	BCR	Calculate the BCR of the project options by dividing the PV total net benefits **(7)** by the PV total net costs **(18)**.

Worksheet 3: Benefit cost analysis, continued

Benefit cost analysis **Worksheet 3**

	Benefits	PV of benefits as calculated				PV of net benefits (PV option – PV do min benefits)		
		Do min	Option A	Option B	Option C	Option A	Option B	Option C
1	Travel time savings	1,700,000	1,550,000	1,400,000	1,100,000	150,000	300,000	600,000
2	VOC savings	1,900,000	1,400,000	1,400,000	1,000,000	500,000	500,000	900,000
3	Accident cost savings	1,800,000	1,450,000	1,250,000	900,000	350,000	550,000	900,000
4	Vehicle emission reductions	95,000	70,000	70,000	50,000	25,000	25,000	45,000
5	Reduced driver frustration							
6	Monetised external impacts (list)							
7	**PV total net benefits**					1,025,000	1,375,000	2,445,000
	Costs	**PV of costs as calculated**				**PV of net costs (PV option – PV do min costs)**		
8	Investigation							
9	Design		27,000	54,000	54,000	27,000	54,000	54,000
10	Property				100,000			100,000
11	Construction/ implementation (incl. preconstruction)	0	128,000	246,000	266,000	128,000	246,000	266,000
12	Maintenance	65,000	40,000	40,000	45,000	-25,000	-25,000	-20,000
13	Renewal							
14	Operating		10,000	5,000	10,000	10,000	5,000	10,000
15	External impact mitigation							
16	Project contingency		10,000	20,000	40,000	10,000	20,000	40,000
17	Risk management							
18	**PV total net costs**					150,000	300,000	450,000
19					**BCR = (7)/(18) =**	6.8	4.6	5.4

Worksheet 4: Incremental analysis

Explanation sheet for incremental analysis **Worksheet 4**

This worksheet is used to calculate the incremental BCR of the project options ranked in order of increasing cost. The procedure is repeated for all project options.

1	Target incremental BCR	Enter the target incremental BCR as selected from appendix A12.4.
2	Option	Enter the base option for comparison as follows: • Step 1: the lowest cost project option. • Subsequent steps: the base option for the next step from **(11)** of the previous iteration.
3	Costs	Enter the PV total net cost of the base option from worksheet 3, row **(18)**.
4	Benefits	Enter the PV total net benefits of the base option from worksheet 3, row **(7)**.
5	Option	Enter the next higher cost project option not previously analysed.
6	Costs	Enter the PV total net cost of the next higher cost project option from worksheet 3, row **(18)**.
7	Benefits	Enter the PV total net benefits of the next higher cost project option from worksheet 3, row **(7)**.
8	Incremental costs	Calculate the incremental costs by subtracting the cost of the lowest cost project option **(3)**, from the cost of the next higher cost project option **(6)**.
9	Incremental benefits	Calculate the incremental benefits by subtracting the benefits of lowest cost project option **(4)** from the benefits of the next higher cost project option **(7)**.
10	Incremental BCR	Calculate the incremental BCR by dividing the incremental benefits **(9)** by the incremental costs **(8)**.
11	Base option for next step	Select the base option for comparison for the next step. If the incremental BCR is less than the target incremental BCR, discard the higher cost project option in favour of the base option. If the incremental BCR is greater than the target incremental BCR, then the higher cost project option is chosen as the base option for the next step.
12	Preferred project option	Select the preferred project option.
13	Rationale for selection	If the highest cost project option with an incremental BCR greater than the target incremental BCR is not the preferred project option, provide the rationale for this decision.
14	Sensitivity test of incremental analysis	Repeat the process above using a target incremental ratio 1.0 higher than that selected in **(1)**. For example, if the target incremental ratio is 3.0, test the preferred project option by using a target incremental BCR of 4.0. Report on this analysis as indicated.

Worksheet 4: Incremental analysis, continued

Incremental analysis - EXAMPLE **Worksheet 4**

1 Target incremental BCR (from appendix A12.4) 4.0

Step	Option	Base option for comparison			Next higher cost option			Incremental analysis		
		Costs	Benefits	Option	Costs	Benefits	Incremental costs	Incremental benefits	Incremental BCR	Base option for next step
	(2)	(3)	(4)	(5)	(6)	(7)	(8) = (6) - (3)	(9) = (7) - (4)	(10) = (9) - (8)	(11)
1	A	150,000	1,100,000	B	300,000	1,500,000	150,000	400,000	2.7	A
2	A	150,000	1,100,000	C	450,000	2,600,000	300,000	1,500,000	5.0	C
3	C	450,000	2,600,000	D	700,000	3,700,000	250,000	1,100,000	4.4	D
4	D	700,000	3,700,000	E	1,000,000	4,200,000	300,000	500,000	1.7	D
5										
6										
7										
8										

12 Preferred project option option D

13 Rationale for selection

14 Results of sensitivity testing of target incremental BCR

Worksheet 5: First year rate of return

Explanation sheet for first year rate of return **Worksheet 5**

This worksheet is used to calculate the first year rate of return for the preferred project option.

1	Preferred project option	Enter the preferred project option from worksheet 4, row **(12)**.
2	PV of total net cost	Enter the PV of total net cost of the preferred option from worksheet 3, row **(18)**.
3	Mid-point of first year benefits	Enter the mid-point of the first year of benefits relative to time zero by adding six months to the end of construction. For example, if the end of construction is 1¾ years after time zero, the mid-point of the first year of benefits is 2¼ years after time zero.
4	Discount factor (SPPWF) of first year of benefits	Enter the SPPWF corresponding to the mid-point of the first year of benefits from table A1.2 in appendix A1..
5	Annual benefits of preferred option (at time zero)	Enter the undiscounted (time zero) value of the net annual benefits for the preferred option from worksheet 2, column **(4)**.
6	Annual benefit of the do minimum (at time zero)	Enter the undiscounted (time zero) value of the net annual benefits for the do minimum from worksheet 2, column **(4)**.
7	Annual net benefit of preferred option (at time zero)	Enter the undiscounted (time zero) value of the net annual benefit by subtracting the do minimum value **(5)** from the preferred option value **(6)**.
8	Growth rate	Enter the growth rate at time zero from worksheet 1.
9	PV of benefits in first year	Calculate the PV of the first year benefits using the formula shown on the worksheet.
10	PV of total net benefits in first year	Sum the PV of all the net benefits to get the PV total net benefits in the first year.
11	FYRR	Calculate the first year rate of return by dividing the PV of the first year of benefits **(10)** by the PV of the total net costs **(2).** Express this as a percentage by multiplying the result by 100.

Worksheet 5: First year rate of return, continued

First year rate of return - EXAMPLE **Worksheet 5**

1	Preferred project option	D
2	Present value of total net costs	$500,000
3	Mid point of first year of benefits (relative to time zero)	2.25
4	Discount factor (SPPWF) for first year of benefits	0.8070

Benefit	Annual benefits of preferred option (5)	Annual benefits of do minimum (6)	Net annual benefit (at time zero) (7)	Growth rate (decimal) (8)	PV of benefits in first year (9)=[1.0+(3)x(8)]x(4)x(7)
Travel time savings	200,000	100,000	100,000	0.02	84,330
Vehicle operating cost savings	100,000	50,000	50,000	0.02	42,170
Accident cost savings	250,000	200,000	50,000	0.01	41,260
Reduced driver frustration			N/A	0.02	
Vehicle emissions reductions	5,000	2,500	2,500	0.02	2,110
External impacts					
Vehicle emissions	50,000	30,000	20,000	0.02	16,140

10	Sum of present value of benefits in first year	$186,010
11	First year rate of return [**(8)**/**(2)** × 100]	37%

Worksheet 6: Sensitivity analysis

Explanation sheet for sensitivity analysis **Worksheet 6**

This worksheet is used to analyse the sensitivity of the project results to variations in the major input parameters.

1	Preferred project option	Enter the preferred project option from worksheet 4, row **(12)**.
2	BCR	Enter the BCR of the preferred project option from worksheet 3, row **(19)**.
	Assumptions	
3	Variable	Enter the variables to which the project is particularly sensitive. These may include: maintenance costs, traffic volumes, travel times or speeds, road roughness, accident reduction, other external impacts, and others.
4	Assumptions	Describe the assumptions made to arrive at the value of the variable used in the evaluation. Explain the basis for the proposed lower and upper bounds of the variable
	Base case	
5	Value	Enter the value of the variable used in the evaluation.
	Lower bound	
6	Value	Determine the lower bound value for the variable.
7	BCR	Calculate the BCR that results from using the lower bound of the variable, following the procedure in worksheet 3.
	Upper bound	
8	Value	Determine the upper bound value for the variable.
9	BCR	Calculate the BCR that results from using the upper bound of the variable, following the procedure in worksheet 3.

Worksheet 6: Sensitivity analysis, continued

Sensitivity analysis **Worksheet 6**

1 Preferred project option _____

2 BCR _____

Variable (3)	Basic assumptions (4)
Maintenance costs	
Traffic volumes	
Travel times or speeds	
Road roughness	
Accident reduction	
External impacts	
Others (list)	

Variable (3)	Base case	Lower bound		Upper bound	
	Value (5)	Value (6)	BCR (7)	Value (8)	BCR (9)
Maintenance costs					
Traffic volumes					
Travel times or speeds					
Road roughness					
Accident reduction					
External impacts					
Others (list)					

Worksheet 7: Checklist for project evaluations

Explanation sheet for checklist for project evaluations **Worksheet 7**

The checklist should be used to check that the evaluation is complete and presented in sufficient detail to allow the project to be forwarded for consideration for funding. Space is provided for comments or explanations if necessary. Where a component is 'not applicable' and the reason for this is not obvious, it may be helpful to comment on this. Space is provided at the bottom of the checklist for general comments.

For each component of the evaluation, indicate whether or not:

1. the calculation(s) has been done accurately
2. the information is complete
3. the assumptions made about the component are valid

Mark Y = yes, N = no or NA = not applicable as appropriate.

Make any comments as suggested above.

Worksheet 7: Checklist for project evaluations, continued

Checklist for project evaluations **Worksheet 7**

Project name _____

Preferred option _____

Component of the evaluation:		Has this component been checked for: Y = Yes, N = No, or NA = not applicable			Comments
		Accuracy of calculations (1)	Completeness of information (2)	Validity of assumptions (3)	
Project capital costs	Do-minimum				
	Option				
Maintenance costs	Do-minimum				
	Option				
Travel time savings	Do-minimum				
	Option				
VOC savings	Do-minimum				
	Option				
Accident cost savings	Do-minimum				
	Option				
Monetised external impacts					
Time stream of costs and benefits					
Discounting	Benefits				
	Costs				
BCR					
Incremental analysis					
First year rate of return					
Transport model validation					
Sensitivity analysis					
General comments					

Worksheets 8: Transport modelling checks

Explanation sheet for coarse check on transportation model outputs **Worksheet 8.1**

1	Project name	Enter the project name.
2	Road section travel time	Enter the total travel time for road sections for each of the do minimum and the project option, for each of the first year of benefits and the future year, and calculate the travel time savings.
3	Intersection delay	Enter the total intersection delay for each of the do minimum and the project option, for each of the first year of benefits and the future year, and calculate the savings.
4	Total travel time	Calculate the totals by summing the columns above.
5	Daily travel time benefit	Calculate the daily travel time benefit for each of the first year and the future year by multiplying the total time **(4)** by the value of travel time from appendix A4.
6	Daily traffic using project	Enter the daily total traffic which will use the new facility.
7	Travel time savings	Calculate the travel time savings by dividing the total travel time **(4)** by the total traffic using the project **(6)**.
8	Travel time benefits	Calculate the travel time benefits per vehicle by dividing the daily travel time benefit **(5)** by the total traffic using the project **(6).**
9	Comment	Add any comments that may be relevant.

Worksheets 8: Transport modelling checks, continued

Coarse check on transportation model outputs **Worksheet 8.1**

1 Project name _____

		Do minimum		Project option		Savings	
		First year	**Future year**	**First year**	**Future year**	**First year**	**Future year**
2	Road section travel time (mins)						
3	Intersection delay (mins)						
4	Total time (mins)						

		First year	Future year
5	Daily travel time benefit ($)		
6	Daily traffic (vehicles)		
7	Travel time savings (min/vehicle)		
8	Travel time benefits ($/vehicle)		

9 Comment _____

_____

_____

_____

Worksheets 8: Transport modelling checks, continued

Explanation sheet for detailed checks on transportation model outputs **Worksheet 8.2**

The detailed checks in worksheet 8.2 comprise a total of 21 steps. Steps **(3)** to **(16)** are repeated for each time period (eg, AM peak, interpeak, PM peak, etc). Worksheet 8.2(e) compares the results of detailed check with the stated annual travel time benefit value in the evaluation.

	Worksheet 8.2(a)	**Typical road section speeds**
1	Project name	Enter the project name.
2	Analysis year	Enter the analysis year. One sheet will be required for each analysis year and analysis time period.
3	Analysis time period	Enter the analysis time period, eg, AM peak, interpeak, or PM peak.
4	Typical road section speeds	For those roads most affected, enter the length, traffic volumes and speeds for the do minimum and the project option.
	Worksheet 8.2(b)	**Critical intersections**
5	Intersections	Identify all of the critical intersections for both the do minimum and the preferred project option.
6	Volume	Enter the traffic volume (vehicles/hour) on the most congested approach for each critical intersection for the do minimum and the project option.
7	Delay	Enter the delay (seconds/vehicle) on the most congested approach for each critical intersection for the do minimum and the project option.
	Worksheet 8.2(c)	**Journey components**
8	Journey component	Identify the journey components which receive the greatest benefit for the do minimum and the option.
9	Component travel time	Enter the travel time per vehicle (seconds/vehicle) for each of the identified journey components.
	Worksheet 8.2(d)	**Journeys**
10	Journey	Sum the journey components from **(9)** to get journeys. Enter an identifying name for the journey.
11	Journey travel time savings	Calculate the difference between the do minimum and the option to get the travel time savings per vehicle.
12	Trips	Enter the number of vehicles trips which incorporate the journey.
13	Travel time savings per journey	Multiply the number of trips **(12)** by the travel time savings per vehicle **(11)** to get the total travel time savings for the journey **(13)**.
14	Total travel time savings	Sum all journeys to get the total travel time savings (in seconds).
15	Unit cost	Select the appropriate value of travel time savings for the road type from appendix A4.
16	Travel time savings benefit	Multiply **(14)** by the unit cost **(15)** to get the total benefit.
	Worksheet 8.2(e)	**Summary of detailed checks**
17	Time period	Enter each time period **(3)** analysed in the detailed check.
18	Total benefit in the time period	Enter the total benefit for each time period as calculated in **(16)**.
19	Time periods per year	Enter the number of times the benefit time period **(17)** occurs in a year.
20	Total benefits per year	Multiply the number of time periods per year **(19)** by the benefits per time period **(18)** to get total benefits per year **(20)**.
21	Total annual travel time benefits	Sum the benefits over all time periods in **(20)** to get total annual travel time benefits and compare with travel time benefits in the project evaluation report.

Worksheets 8: Transport modelling checks, continued

Detailed checks on transportation model outputs **Worksheet 8.2(a)**

Typical road section speeds

1 Project name _____

2 Analysis year _____

3 Analysis time period (am, ip, pm, etc) _____

Road name (4)	Length (metres)	Volume (vehicles/hour)		Speed (km/h)		Time (seconds)	
		Do min	Option	Do min	Option	Do min	Option

Worksheets 8: Transport modelling checks, continued

Detailed checks on transportation model outputs **Worksheet 8.2(b)**

Critical intersections

Intersection (5)	Volume (vehicles/hour) (6)		Delay (seconds/vehicle) (7)	
	Do minimum	Option	Do minimum	Option

Worksheets 8: Transport modelling checks, continued

Detailed checks on transportation model outputs **Worksheet 8.2(c)**

Journey components

Journey/component (8)	Travel time (seconds/vehicle) (9)	
	Do minimum	Option

Worksheets 8: Transport modelling checks, continued

Detailed checks on traffic model outputs **Worksheet 8.2(d)**

Journey

Journey (10)	Travel time (seconds/vehicle) (11)			Trips (12)	Travel time savings (seconds) (13)
	Do minimum	Option	Savings		

14 Total travel time savings _____

15 Unit cost _____

16 Total benefit _____

Worksheets 8: Transport modelling checks, continued

Detailed checks on traffic model outputs **Worksheet 8.2(d)**

Summary of detailed checks and comparison with evaluation values

Time period (17)	Total benefit in time period (18)	Time periods per year (19)	Total benefits per year (20)

21 Total annual travel time benefits for option _____

Annual travel time benefits in economic evaluation _____

Percentage of travel time benefits explained by check _____

Worksheets 8: Transport modelling checks, continued

Explanation sheet for project model specification checklist **Worksheet 8.3**

Worksheet 8.3 may be used as a guideline to checking that the specification of the project model reflects good practice and is appropriate for the project being evaluated. A checklist of suggested information is listed on the worksheet, which may be included with information for the model reviewer.

In section A, part (4), several time periods should be chosen for the analysis so that the model adequately reflects the changing flow profile across a day.

The worksheet is completed by ticking the boxes as appropriate.

Worksheets 8: Transport modelling checks, continued

Project model specification checklist **Worksheet 8.3**

A General information

Tick if a model specification statement has been included for the following:

	1. Type of model used, together with reasons for selecting that model
	2. Geographic area covered by the model study area and density of zones
	3. Network detail (eg, motorways/arterials/minor streets, number of links)
	4. Time periods modelled (eg, AM peak 7:30 – 9:00am, interpeak 9:00am – 4:30pm)
	5. Vehicle types included (eg, car, light, heavy commercial vehicles)
	6. How external trips are handled (eg, external or cordon zone system)
	7. Other (please specify)

B Data sources

Tick if a description of the data source and the source's reliability (eg, errors, biases, consistency) have been provided for the following:

	1. Network data (eg, link lengths, free flow speeds, capacities, posted speed limits, number of lanes, intersection types)
	2. Travel data and collection methods (eg, traffic counts, speeds, origin-destination surveys)
	3. Interface with external demand modelling (eg, outputs from a sub-regional model)
	4. Other (please specify)

C Matrices

Tick if a statement of the following has been provided:

	1. Description of each step in the assembly of the base year trip matrices, including methods, assumptions and factors applied (eg, derivation from external demand model, ME2 matrix estimation procedures)
	2. Matrix fit to observed data (eg, screenlines, comparison with independent origin and destination flows). Note: if the ME2 estimation procedure is used to estimate matrices from traffic counts, an independent validation will only be obtained if different counts are used to validate the model.
	3. If variable matrix methods or growth constraint techniques have been used, a statement of the method and parameters adopted, and justification of the approach
	4. Other (please specify)

Worksheets 8: Transport modelling checks, continued

Project model specification checklist **Worksheet 8.3**, continued

D Assignment

Tick if a specification statement has been provided for the following:

	1. Description of how the network was constructed
	2. Assignment method (eg, incremental, equilibrium)
	3. Generalised cost function used for routing
	4. Volume-delay functions (eg, equations, coefficients, calibration)
	5. Basis of intersection delay modelling (lane-by-lane, approach-based, SIDRA computations)
	6. Other (please specify)

E Forecasting

Tick if a specification statement has been provided for the following:

	1. Comparison of forecast year growth rates with historical trends (may include land use, household size, car ownership, traffic volumes, commercial vehicle volumes)
	2. Checks of average growth across selected screenlines to ensure local growth is reasonable
	3. Comparisons with other forecasts
	4. Other (please specify)

F Project models that include strategic demand elements

If travel demand (including mode choice) is modelled within the project model, rather than in an external demand model, the demand elements of the project model should be validated in accordance with part C of worksheet 8.5

Worksheets 8: Transport modelling checks, continued

Explanation sheet for base year assignment validation **Worksheet 8.4**

Worksheet 8.4 may be used as a guide to checking that present-year assignment results are consistent with observed flows and times in the base network. For the validation, a reasonable range of links and intersections relevant to the project evaluation should be chosen. Typically, this would include links in the scheme corridor, along with a sample of links outside the corridor.

Usually preliminary checks of the assignment model are conducted to verify that the model has been initialised correctly. These pre-checks need not be reported, but should be included in the validation of the model. The pre-checks and other validation checks outlined in the checklist should be carried out for each time period used in the evaluation.

A Link flows

1. Link volume plots (*mandatory check*)

   For each time period, produce a map of the network showing modelled and observed link volumes and the differences between them. Totals should be summarised for available screenlines. If the assignment software does not generate these plots automatically, manually annotating a map of the study area with the relevant volumes could be considered. These plots will be used to check modelled and observed volumes by geographic area and level of flow.

   Given the recognised potential for error in the traffic counting method and/or in the sampling method, which will result in some variation between modelled and observed volumes, an allowance for error in observed volumes should be allowed when judging the fit of the model.

   Generally, a reasonable error tolerance for hourly volumes on most individual major links (eg, carrying in excess of 15,000 vehicles per day in one direction) would be approximately ±20%. For links carrying less traffic, the error tolerance may be greater than this, providing that the links do not significantly affect the project evaluation. In the case of screenlines, the advisable error tolerance will be narrower – in the majority of cases less than ±10%.

   Where errors fall outside reasonable tolerances, the relevant links should be highlighted on the link volume plot.

2. Scatter plot of observed and modelled flows (*mandatory check*)

   Produce an XY scatter plot of modelled versus observed flows for:

   - all individual links and
   - screenlines.

   Superimpose the line y=x on each plot.

   Report the coefficient of determination (R^2) for each plot. Generally, the coefficient should be greater than 0.85, and greater than 0.95 in the vicinity of the scheme. Outliers may be acceptable, providing that they are within reasonable bounds and the flows on the corresponding links do not affect the project evaluation.

Worksheets 8: Transport modelling checks, continued

Explanation sheet for base year assignment validation **Worksheet 8.4**, continued

3. GEH statistic (*recommended check*)

   The GEH statistic is a form of Chi-squared statistic that is designed to be tolerant of larger errors in low flows. It may be computed for individual hourly link flows and also for hourly screenline flows. The GEH statistic has the following form:

$$\sqrt{\frac{(q_{model} - q_{obs})^2}{(q_{model} + q_{obs})^2}}$$

   Where q^{obs} = observed hourly flow

   q^{model} = modelled hourly flow

   It should be noted that the GEH statistic applies to hourly flows only. Total time period flows should be converted to hourly flows before using the above formula. In the checks:

   - At least 60% of individual link flows should have GEH less than 5.0.
   - At least 95% of individual link flows should have GEH less than 10.0.
   - All individual link flows should have GEH less than 12.0
   - Screenline flows should have GEH less than 4.0 in most cases.

4. Percentage root-mean-square error (RMSE) (*recommended check*)

   Unlike the GEH statistic (which applies to individual flows and screenlines), the root-mean-square error applies to the entire network.

   The percentage RMSE is calculated as:

$$\%\ RMSE = \frac{\sqrt{\frac{\sum(q_{model} - q_{obs})^2}{\text{Number of counts - 1}}}}{\left(\frac{\sum q_{obs}}{\text{Number of counts}}\right)} \times 100$$

   In general, the RMSE should be less than 30%.

5. Vehicle kilometres travelled (VKT) (*optional check*)

   If data on actual VKT are available, measurements of modelled VKT in the study area should be within 5% of observed VKT.

Worksheets 8: Transport modelling checks, continued

Explanation sheet for base year assignment validation **Worksheet 8.4**, continued

B Intersection flows and delays

1. Intersection turning flow plots *(mandatory check*)

   For each intersection critical to the scheme appraisal, provide a diagram showing the modelled and observed turning flows at the intersection. Diagrams should be produced for each time period of the analysis. As a general guide, modelled turning flows should be within 30% of observed flows.

2. Intersection approach delays (*optional check*)

   Where delay information is available, provide a diagram showing modelled and observed approach delays for intersections critical to the scheme appraisal.

3. Intersection queue lengths (*optional check*)

   Where queue length information is available, provide a diagram showing modelled and observed queue lengths for intersections critical to the scheme appraisal.

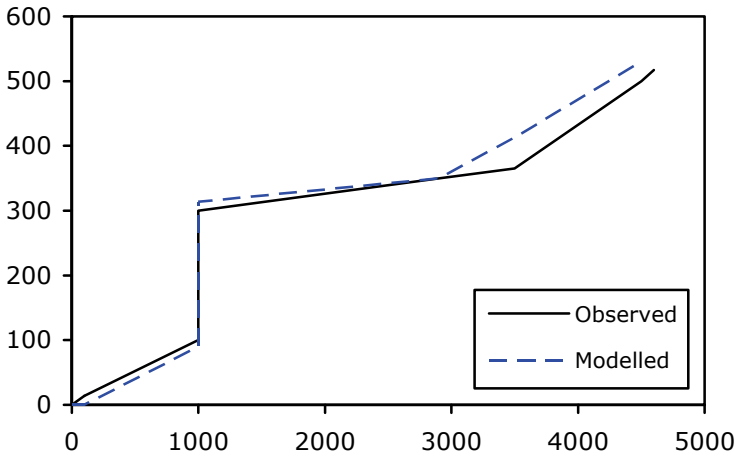
C Journey times and speeds

1. Corridor travel time plots (*mandatory check)*

   Provide a comparison of modelled and observed journey times, either as an XY scatter plot (with the line y=x superimposed on it) or as a simple table of values. Comparisons should be provided for each time period in the analysis.

2. Cumulative travel time plots (*recommended check*)

   For corridors relevant to the project evaluation, plot cumulative travel time by distance for modelled and observed runs. A sample plot is shown below:



3. Link speed plots (optional)

   On a map of the network, produce a diagram showing modelled link speeds. For each time period in the analysis, verify that link speeds are consistent across the network.

Worksheets 8: Transport modelling checks, continued

Explanation sheet for base year assignment validation **Worksheet 8.4**, continued

D Assignment convergence and stability

Assignment convergence may be verified using a summary sheet for each project option and time period. The sheet is filled out as follows:

1	Project name	Enter the project name.
2	Assignment software and version	Enter the name and version of the assignment program used to model the project.
3	Type of assignment	Enter the assignment type (eg, equilibrium, incremental, volume-averaging).
4	Convergence achieved at iteration number	Enter the number of iterations required for convergence.
5	Percentage change in total generalised user cost	Enter the percentage change in total generalised user cost in the final iteration. For stability, there should be consecutive iterations with percentage change less than 1%.
6-8	Other stability and convergence parameters	Enter at least one additional convergence performance indicator. Several appropriate indicators are suggested below.

As a general guideline, the degree of assignment convergence should be such that the difference in project benefits computed from successive iterations is only a small fraction of the total project benefit. The following measures are suggested:

- The proportion of links in the entire network with flows changing less than 5% from the previous iteration.
- For stability there should be consecutive iterations with proportion greater than 95%.
- Where available, the 'normalised gap', δ, which expresses the flow-weighted difference between current total costs and the costs incurred if all traffic could use minimum cost routes, should be less than 1% for convergence.
- Other measures of stability and convergence provided by transportation modelling packages may also be included.

Worksheets 8: Transport modelling checks, continued

Base year assignment validation **Worksheet 8.4**

A Link and screenline flows

Tick if the following validation information has been provided:

	1. Link volume plots (mandatory)
	2. Scatter plots of observed and modelled flows (mandatory)
	3. GEH statistic for critical screenline flows and individual link flows (recommended)
	4. Percentage root-mean-square error (recommended)
	5. Comparison of modelled vehicle kilometres travelled with observed values (optional)
	6. Other (please specify)

B Intersection flows and delays

Tick if the following validation information has been provided:

	1. Intersection turning flow plots (mandatory)
	2. Intersection approach delays (optional)
	3. Intersection queue lengths (optional)
	4. Other (please specify)

C Journey times and speeds

Tick if the following validation information has been provided:

	1. Corridor travel time plots (mandatory)
	2. Cumulative travel time plots (recommended)
	3. Link speed plots (optional)
	4. Other (please specify)

Worksheets 8: Transport modelling checks, continued

Base year assignment validation **Worksheet 8.4**, continued

D Assignment convergence and stability

1 Project name _____

2 Assignment software and version _____

3 Type of assignment _____

Do minimum

	Run year	Base	Forecast			
			Year 1	Year 2	Year 3	Year 4
4	Convergence achieved at iteration number					
5	Percentage change in total generalised user cost (mandatory)					
6	Proportion of links with flows changing <5% (recommended)					
7	Normalised gap δ (recommended)					
8	Other convergence measure (optional)					

Option

	Run year	Base	Forecast			
			Year 1	Year 2	Year 3	Year 4
4	Convergence achieved at iteration number					
5	Percentage change in total generalised user cost (mandatory)					
6	Proportion of links with flows changing <5% (recommended)					
7	Normalised gap δ (recommended)					
8	Other convergence measure (optional)					

This page is blank

Worksheets 8: Transport modelling checks, continued

Explanation sheet for strategic demand model checks **Worksheet 8.5**

Worksheet 8.5 may be used to check the modelling approaches used in the demand model are appropriate and the outputs of the model are reasonable. The worksheet is completed by filling in the check boxes and comments for each validation topic.

Worksheets 8: Transport modelling checks, continued

Strategic demand model checks **Worksheet 8.5**

A Is there a precedent of approval (reviews or audits) for the demand or sub-regional model used to generate matrices?

- ☐ Yes (no further documentation needs to be supplied)
- ☐ No (proceed to part B below)

B Does Land Transport NZ agree that a full model review is not feasible for the project?

- ☐ Yes (provide evidence of a check that the incoming data from the strategic demand model is reasonable; no further review is required)
- ☐ No (proceed to part C below)

C Full model review

Tick if the following validation information has been provided:

- ☐ 1. A description of the model, including:
  - ☐ the model type and reasons for choosing the model
  - ☐ the zoning system and geographic coverage of the study area
  - ☐ time periods used in the model
- ☐ 2. A specification of data sources, including:
  - ☐ travel surveys: sample sizes, biases and validation
  - ☐ transport network data: digital maps, inventory surveys, timetables, etc.
  - ☐ demographic and employment data
- ☐ 3. A report of the model specification and estimation, including:
  - ☐ variables, equations and coefficients
  - ☐ outputs of statistical estimation procedures
- ☐ 4. Evidence of validation, including:
  - ☐ fit to independent data
  - ☐ comparison with other models
  - ☐ sensitivity tests/elasticities
- ☐ 5. Record of model applications – ideally includes evidence of a successful history of model application
- ☐ 6. Other (please specify) _____

Worksheets A1: Discounting and update factors

Explanation sheet for summary of benefits and costs time streams **Worksheet A1.1**

This worksheet is used to identify the timing of capital costs and the start and end points of the benefit and cost streams. Time zero must be the same for each option evaluated. A separate worksheet is required for each option.

Once the project benefits and costs have been calculated, they are entered on the bar charts to give a picture of the magnitude and incidence of the benefit and cost streams. The duration of benefits and costs are indicated on the bar charts by a bar showing start and end points. Each separate benefit or cost shall have such a bar.

1	Project option	Enter the project option (eg, do minimum, option A).
2	Base date	Enter the base date for costs and benefits.
3	Time zero	Enter time zero.
4	Benefits	Draw a bar on the chart from the start to the end of the time stream for each benefit item.
5	Costs	Draw a bar on the chart from the start to the end of the time stream for each cost item. Where construction is spread over more than one year, an appropriate cost breakdown by year is required, allocating costs to the nearest year start or end.

Worksheets A1: Discounting and update factors, continued

Summary of time streams of benefits and costs **Worksheet A1.1**

Option (1)					**Base date (2)**			1 July 20__				**Time zero (3)**				1 July 20__																											
Time (years from time zero)																																											
Benefits (4)	0				1				2				3				4				5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Travel time savings																																												
VOC savings																																												
Accident cost savings																																												
Vehicle emissions reductions																																												
Reduced driver frustration																																												
Monetised external impacts (list)																																												
Costs (5)	0				1				2				3				4				5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Land																																												
Investigation																																												
Design																																												
Construction																																												
Annual maintenance																																												
Periodic maintenance																																												
Operating																																												
Environmental mitigation																																												
Contingency																																												
Risk mitigation																																												

Worksheets A1: Discounting and update factors, continued

Explanation sheet for discounting and update factors **Worksheet A1.2**

This worksheet is used for discounting future costs and benefits to their present value. More than one worksheet may be required. Refer to appendix A1 for a description of the discounting procedures, and example calculations.

1	Project option	Enter the project option.
2	Base date	Enter the base date.
3	Time zero	Enter time zero.
4	Type of cost or benefit	Enter the type of benefit or cost, eg, construction, maintenance, travel time etc. Only one benefit or cost type is entered in each column
5	Year of estimate	Enter the year for which the benefit or cost was estimated, if different from base date.
6	Single payment	Calculate the present value of single payments as follows: **(a)** Enter the amount **(b)** Enter the time when the benefit or cost is measured (in years since time zero) **(c)** Enter the SPPWF for that time, refer table A1.1, Appendix A1. **(d)** Calculate the PV at time zero = amount x SPPWF. Provision is made for 2 single payments, so for instance a construction project which is built over 2 years can be accommodated in one column. If longer than 2 years, use extra columns and add together to get a total.
7	Uniform series	Calculate the PV of a uniform series as follows: **(a)** Enter the amount of the cost or saving in dollars per year **(b)** Enter the start time s of the benefit or cost streams (in years since time zero) **(c)** Enter the end time e of the benefit or cost streams (in years since time zero) **(d)** – **(e)** Enter the USPWF for s years; and the USPWF for e years – refer table A1.1. **(f)** Calculate the present value at time zero = annual amount x {USPWFe – USPWFs}.
8	Arithmetic series	Calculate the PV of an arithmetic growth series as follows: **(a)** Enter the initial amount (at time zero) of the benefit or cost in dollars per year **(b)** Enter the growth rate, expressed as a decimal fraction, eg, 3% is 0.03. The growth rate for accidents is adjusted as per appendix A6.4 **(c)** Enter the start time of the benefit or cost stream (in years since time zero) **(d)** Enter the end time of the benefit or cost stream (in years since time zero) **(e)** – **(h)** Enter the USPWF for s years; the USPWF for e years; the AGPWF for s years; and the AGPWF for e years – refer table A1.1 **(i)** Calculate the PV at time zero: Initial amount x [(USPWFe – USPWFs) + (growth rate x {AGPWFe – AGPWFs})].
9	Total PV time zero	Where necessary, sum the single payments in a column to get the total PV of the benefit or cost at time zero. Otherwise, transfer the PV of the benefit or cost from **6(d)**, **7(f)** and **8(i)**.
10	Update factor	If the year in which the benefits or costs were estimated is different from base date, use update factors from appendix A12.3 to convert benefits and costs to the base date.
11	Total PV time zero adjusted to base date	Multiply **(9)** by **(10)**. Transfer this value to the appropriate line in worksheet 3.

Worksheets A1: Discounting and update factors, continued

Discounting and updating factors - EXAMPLE **Worksheet A1.2**

1	Project option	
2	Base date	
3	Time zero	

4 Type of benefit or cost	Periodic reseal	Construction	Maintenance	VOC
5 Year of estimate (1 July 20__)	2006	2005	2006	2002
6 Single payment				
(a) Amount	50,000	530,000		
(b) time, n	15	1		
(c) SPPWF for time n	0.2394	0.9091		
(d) PV time zero **(a)** x **(c)**	11,970	481,820		
6 Single payment				
(a) Amount		850,000		
(b) time, n		2		
(c) SPPWF for time n		0.8264		
(d) PV time zero **(a)** x **(c)**		702,440		
7 Uniform series				
(a) annual amount			30,000	
(b) start time, s			0	
(c) end time, e			27	
(d) USPWF for s years			0	
(e) USPWF for e years			9,692	
(f) PV time zero **(a)** x [**(e)** – **(d)**]			290,760	
8 Arithmetic growth				
(a) initial amount (time zero)				70,000
(b) arithmetic growth rate				0.03
(c) start time, s				2
(d) end time, e				27
(e) USPWF for s years				1,821
(f) USPWF for e years				9,692
(g) AGPWF for s years				1,763
(h) AGPWF for e years				80,078
(i) PV time zero **(a)** x [**(f)** – **(e)** + **(b)** x {**(h)** – **(g)**}]				715,430
9 Total PV time zero	11,970	1,184,260	290,760	715,430
10 Update factor for year of estimate	1.00	1.09	1.00	1.30
11 Total PV time zero at base date (9) x (10)	11,970	1,290,840	290,760	930,060

Worksheets A2: Traffic data

Explanation sheet for route data **Worksheet A2.1**

This worksheet is used to list road sections and intersection approaches/traffic movements in accordance with the project location diagram(s) provided in worksheet 1. If there are only a few road sections or intersection approaches/traffic movements for each project option, details of all project options can be recorded on one page.

1	Project option	Enter the project option.
2	Section/movement number	Enter the identifying number of each road section and intersection approach/traffic movement.
3	Length	Enter the length of each road section or intersection approach/traffic movement in metres.
4	Description	Describe each road section or intersection approach/traffic movement in words or location reference points.
5	Traffic direction (for road sections only)	Enter the direction for each road section which may be two-way (ie, both directions) if the gradient is level or nearly level.
6	Gradient	Enter the percent gradient, using the following sign convention • positive (+) for uphill • negative (-) for downhill • plus and minus (±) for two way
7	Road surface	Enter the road surface • S for sealed • U for unsealed roads
8	Road roughness	Enter road roughness, in NAASRA counts per kilometre or IRI, as follows: **Do minimum** Enter the measured values determined from a calibrated survey. In the absence of measured roughness counts, measured values from similar roads nearby can be used. **Project options** Enter expected average roughness over the life of the project based on typical values for similar roads in the area.

Worksheets A2: Traffic data, continued

Route data **Worksheet A2.1**

Project option (1)	Road section/ movement (2)	Length (m) (3)	Description (4)	Traffic direction (5)	Gradient (6)	Road surface (7)	Road roughness (8)

Worksheets A2: Traffic data, continued

Explanation sheet for summary of surveys on traffic data **Worksheet A2.2**

This worksheet is used to summarise data collected from travel time, traffic speed, vehicle occupancy and travel purpose surveys.

1	Road section/movement	Enter the road section or movement number from worksheet A2.1.
2	Date of survey	Enter the start and finish dates (day(s)/month(s)/year) of survey
3	Location of survey station	Enter description of survey location.
4	Type of survey	Enter the traffic characteristic measured by the survey, ie travel time, speed, occupancy or travel purpose.
5	Method of survey	Enter survey method, eg, automatic traffic counter, manual count, etc.
6	Survey time period	Enter the survey time period.
7	Survey duration	Enter the survey duration.

Worksheets A2: Traffic data, continued

Summary of surveys on traffic data **Worksheet A2.2**

1 Road section/movement _____

Start date of survey (2)	Location of survey station (3)	Type of survey (4)	Method of survey (5)	Survey time period (6)	Survey duration (7)

Worksheets A2: Traffic data, continued

Explanation sheet for surveyed average annual daily traffic (AADT) **Worksheet A2.3**

This worksheet is used to calculate the AADT for section or intersection traffic movement. Part A of the worksheet works out the AADT from each individual survey, while Part B establishes the average AADT base on the counts from the surveys in each year combined. Generally, one worksheet will be completed for each road section/movement. Further guidance is found in appendix A2.3 and A2.4.

A	**Calculating AADT from individual surveys**	
1	Road section/movement	Enter the road section or movement number from worksheet A2.1.
2	Date of survey	Enter the date of the survey.
3	Week	Determine the week of the year that the survey was carried out in accordance with appendix A of the Transit New Zealand *Traffic Counting Guidelines*.
4	Week factor	Determine the week factor from appendix A of the Transit New Zealand *Traffic Counting Guidelines*.
5	ADT	Enter the ADT from the survey data.
6	AADT	Calculate the AADT by multiplying **(4)** by **(5)**.
B	**Averaging AADT from all surveys in each year combined**	
7	Year	Enter the year which the AADT was estimated, one column for each year.
8	AADT	Enter the AADT estimates for each year from **(6)**.
9	Average	Calculate the average of the AADT for each year.

Worksheets A2: Traffic data, continued

Surveyed average annual daily traffic (AADT) **Worksheet A2.3**

1 Road section/movement _____

A Calculating AADT from individual surveys

Date of survey (2)	Week (3)	Week factor (4)	ADT (5)	AADT (6) = (4) × (5)

B Averaging AADT from all surveys combined

7	**Year**				
8	**AADT**				
9	**Average**				

Worksheets A2: Traffic data, continued

Explanation sheet for time zero traffic volume and growth rates **Worksheet A2.4**

This worksheet is used to calculate traffic volumes and growth rates at time zero for a road section or movement from traffic counts. Refer appendix A2.6 and A2.7 for further guidance.

1	Project option	Enter the project option.
2	Road section /movement	Enter the road section or movement number from worksheet A2.1.
3	Time period	Enter the time period for the counts, eg, day, weekday, weekend day, morning peak (7-9am), etc.
4	Year	Enter the year of the traffic count.
5	AADT or average volume	Enter the AADT or average traffic volume for the year. AADTs is obtained from worksheet A2.3.
	Where a full time series of traffic counts (eg, continuous counts) is available:	
6-8	Regression	Perform a linear regression using a suitable programme between the data in **(4)** and **(5)**. Calculate the regression slopes and coefficients.
9	Time zero	Enter the date for time zero.
10	Time zero traffic volume	Calculate the time zero traffic volume using the regression model.
11	Growth rate at time zero	Calculate the growth rate at time zero being the X coefficient **(7)** divided by the time zero traffic volume **(10)** as a percentage.
	Where no full time series of traffic counts is available:	
9	Time zero	Enter the date for time zero.
11	Growth rate at time zero	Determine the growth rate, being the default value growth rate given in appendix A2, table A2.5, the growth rate for the area based on traffic surveys or traffic demand forecasts.
10	Time zero traffic volume	Calculate the increase in traffic volume by multiplying the latest traffic volume **(5)** by the traffic growth **(11)** and the number of years between the latest traffic volume and time zero. Add this increase to the latest traffic volume to get the time zero traffic volume.

Worksheets A2: Traffic data, continued

Time zero traffic volume and growth rates **Worksheet A2.4**

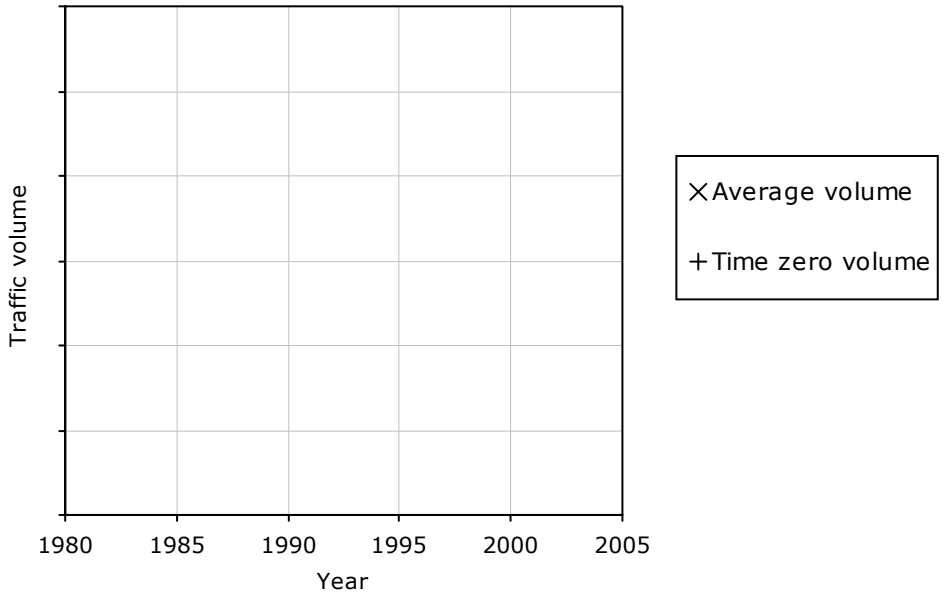
1 Project option _____

2 Road section/movement _____

3 Time period _____

Year (4)	AADT or average volume (5)

	Regression output	
6	**Constant**	
7	**X coefficient**	
8	**R squared**	



9 Time zero _____

10 Time zero traffic volume _____

11 Growth rate at time zero _____

Worksheets A2: Traffic data, continued

Explanation for part week traffic volumes **Worksheet A2.5**

This worksheet is used to calculate part week traffic volumes such as weekday and weekend/holiday where the time period differs from that used in the time zero traffic volume calculation in worksheet A2.4. Appendix A2.6 provides further guidance.

1	Road section/ movement	Enter the road section or movement number from worksheet A2.1.
2	AADT	Enter the AADT from worksheet A2.4.
3	Traffic pattern control group	Determine the traffic pattern control group in accordance with the Transit New Zealand *Traffic Counting Guidelines*.
4	Day	Enter the day(s) for which the traffic volume is being determined, eg, weekday, weekend/holiday.
5	Day factor	Determine the day factor from the Transit New Zealand *Traffic Counting Guidelines*. If the average volume for more than one day is being calculated, then the factor to be used is the average of the factors for those days.
6	Part week traffic volume	Calculate the daily traffic volume for the part week period by dividing the AADT **(2)** by the day factor **(5)**.

Worksheets A2: Traffic data, continued

Part week traffic volumes **Worksheet A2.5**

Road section /movement (1)	AADT (2)	Traffic count control group (3)	Day (4)	Day factor (5)	Traffic volume (6) = (2)/(5)

Worksheets A2: Traffic data, continued

Explanation sheet for part day traffic volumes **Worksheet A2.6**

This worksheet is used to calculate the part day (eg, peak period) traffic volumes where the time period differs from that used in the time zero traffic volume calculation in worksheet A2.4. Appendix A2.6 provides further guidance.

1	Road section/movement	Enter the road section or movement number from worksheet A2.1.
2	Time interval	Enter the time interval, eg, 15 minute interval during peaks, AM peak, 7:00-9:00AM, etc.
3	Day	Enter the day to which the volume applies, eg, Wed, Mon-Fri.
4	Traffic volume	Enter the traffic volume for the time interval from the survey data.
5	Average day factor	Calculate the average day factor being the factor to convert the data from the survey day to the average for the part week, eg, to factor Thursday data to average weekday calculate the factor by dividing the day factor for Thursday by the average of the Monday through Friday factors. If the survey data covers the days required, then the day factor is 1.0.
6	Week factor	Enter the week factor as determined on worksheet A2.3.
7	Part day volume	Calculate the traffic volume for the time interval by multiplying the traffic volume **(4)** by the day factor **(5)** by the week factor **(6)**.

Worksheets A2: Traffic data, continued

Part day traffic volumes **Worksheet A2.6**

Road section/ movement (1)	Day (2)	Time interval (3)	Traffic volume (4)	Day factor (5)	Week factor (6)	Part day traffic volume (7) = (4) x (5) x (6)

Worksheets A2: Traffic data, continued

Explanation sheet for traffic volume forecasts **Worksheet A2.7**

This worksheet is used to provide forecasts of traffic volumes over the analysis period for the do-minimum for each time period for each project option. Properly calibrated and validated transport models (see worksheets A8) may be used for the forecast.

1	Option	Enter the option number.
2	Road section/ movement	Enter the road section or movement number from worksheet A2.1.
3	Time period	Enter the time period. The time period may be a part of a day or all day.
4	Growth period	Divide the analysis period into growth periods during which the traffic growth rate can be assumed approximately constant. Enter the start and finish times, in years after time zero.
5	Number of years	Calculate the number of years in the growth period (subtract the finish year from the start year.
6	Vehicle class	Specify the vehicle class in accordance with appendix A2.2, eg, car, LCV etc, or alternatively one of the standard traffic mixes eg, rural strategic etc. Vehicle classes may be combined.

For each of the columns **(6)** to **(8)** and **(10)** enter the unit of traffic volume in the column heading, eg, veh/hour, veh/day etc.

7	Start traffic volume:	Enter the traffic volume at the start of the growth period. For the first growth period this will be the existing traffic volume. For later growth periods, it will be the finish traffic volume from the previous growth period.
8	Diverted, generated and intermittent traffic	Enter the volume of traffic diverted by this project or other changes to the roading network, the traffic generated by this project, and any intermittent traffic.
9	Adjusted start traffic volume	Calculate the adjusted start traffic volume by summing **(6)** and **(7)**.
10	Growth rate	Enter the arithmetic growth rate as a percentage.
11	Finish traffic volume	Calculate the increase in traffic volume using the formula provided. Multiply the adjusted start traffic volume **(9)** by the traffic growth rate **(10)** and the number of years in the growth period **(5)**. Add this increase to the adjusted start traffic volume to get the finish traffic volume.
12	Assumptions	Describe the basis for the growth rate and any diverted, generated or intermittent traffic.

Worksheets A2: Traffic data, continued

Traffic volume forecasts **Worksheet A2.7**

1 Project option _____

Road section/ movement (2)	Time period (3)	Growth period (4)	Number of years (5)	Vehicle class (6)	Start traffic volume (veh/___) (7)	Diverted, generated or intermittent traffic volume (veh/___) (8)	Adjusted start traffic volume (veh/___) (9)	Growth rate % (10)	Finish traffic volume (veh/___) (8) × [(1.0+ (9)] × (5) (11)

12 Assumptions _____

Worksheets A2: Traffic data, continued

Explanation sheet for traffic volume by vehicle class **Worksheet A2.7**

This worksheet is used to calculate the volume of traffic in each vehicle class. Appendix A2.2 provides description of vehicle classes. Note that traffic composition information is not provided for **buses**. Separate traffic counts for buses or regional council information should be sought where buses form part of the normal traffic stream.

1	Road section/ movement	Enter the road section or movement identifying number from worksheet A2.1.
2	AADT	Enter the time zero traffic volume from worksheet A2.4 **(10)**.
3	Time period	Enter the time periods for which the survey data requires analysis. The time period may be all day.
4	Traffic volume	Specify the unit in the column heading, eg, veh per hour or veh per day and record the traffic volume in each time period.
5-10	Traffic composition	Calculate the number of vehicles in each time period for each vehicle class defined in appendix A2.2 by applying the proportions or actual counts of each vehicle class surveyed to the traffic volume in the time period. Vehicle classes may be combined. If classification counts have not been undertaken, the standard traffic compositions given in appendix A2, table A2.3 is used. Buses are not included in standard traffic compositions.

Worksheets A2: Traffic data, continued

Traffic volume by vehicle class **Worksheet A2.7**

Road section/ movement (1)	AADT (2)	Time period (3)	Traffic volume (veh/___) (4)	Vehicle class					
				Car (5)	LCV (6)	MCV (7)	HCV I (8)	HCV II (9)	Bus (10)

Worksheets A2: Traffic data, continued

Explanation sheet for speed cycles and delay traffic data **Worksheet A2.8**

This worksheet is used to summarise survey data on travel time or traffic speed, speed changes cycles, stops and queuing or bottleneck delay.

1	Road section/ movement	Enter the road section or movement identifying number from worksheet A2.1.
2	Time period	Enter the time period for the survey (eg, day, weekday, AM peak).
3	Vehicle class	Specify one of the standard classes given in appendix A2.2. Vehicle classes may be amalgamated when individual class volumes are relatively small.
4	Free speed travel time	Enter the free speed travel time derived from the surveys. Cross out the unit (min/km or km/h) that is not appropriate in the column heading.
5	Speed change cycle – high speed	Enter the average speed at which vehicles are travelling before they begin to reduce speed for an impediment, eg, a curve or intersection.
6	Speed change cycle – low speed	Enter the average minimum speed to which vehicles reduce in the speed change cycle. More than one speed change cycle may be included in a road section by using two or more lines in the worksheet.
7	Stop	Enter the average the average number of stops experienced by vehicles for this vehicle class. Near stops, (average minimum speed less than 10 km/h) may be included as stops rather than a speed change. Note that a stop is a simplified method of describing a major speed change cycle. **The same manoeuvre must not be entered as both a speed change and a stop.**
8	Queuing or bottleneck delay	Enter the queuing delay at intersections or the bottleneck delay on road sections.

Worksheets A2: Traffic data, continued

Speed cycles and delay traffic data **Worksheet A2.8**

Road section/ movement (1)	Time period (2)	Vehicle class (3)	Free speed travel time (min/km or km/h) (4)	Speed change cycle		Stops (number) (7)	Queuing or bottleneck delay (mins) (8)
				High (km/h) (5)	Low (km/h) (6)		

Worksheets A2: Traffic data, continued

Explanation sheet for occupancy and travel purpose traffic data **Worksheet A2.9**

This worksheet is used to summarise data on vehicle occupancy and travel purpose, as described in appendix A2.5.

Note that in many cases, particularly for travel purpose, default values from table A2.4 in appendix A2.5 will be used for the project evaluation.

1	Roads section/ movement	Enter the road section or movement identifying number from worksheet A2.1.
2	Time period	Enter the time period (eg, day, weekday, AM peak).
3	Occupancy	Enter the average number of occupants (incl. the driver) for each vehicle class and time period.
4	Percent working	Enter the average percent working for each vehicle class and time period. The definition of working must be as set out in appendix A2.5.
5	Percent commuting	Enter the average percent commuting for each vehicle class and time period.
6	Percent other non-working	Enter the average percent other non-working, ie, other than working and commuting.

Worksheets A2: Traffic data, continued

Occupancy and travel purpose traffic data **Worksheet A2.9**

Road section/ movement (1)	Time period (2)	Occupancy (persons/ vehicle) (3)	Percent working (4)	Percent commuting (5)	Percent other non-working (6)

Worksheets A3: Travel time estimation

Explanation sheet for calculating the peak traffic interval **Worksheet A3.1**

This worksheet is used to calculate the parameters relating to the peak traffic interval for a given time period.

1	Project option	Enter the project option (eg, do minimum, option A, etc)
2	Road section/movement	Enter the road section or movement identifying number from worksheet A2.1.
3	Time period	Enter the time period (eg, AM peak [7-9 am], PM peak [4-6 pm).
4	Length of time interval	Enter the length of the time interval in minutes. This will usually be 5, 10 or 15 minutes.
5	Number of intervals in time period	Calculate the number of intervals in the given time period.
6	Traffic volumes by interval	Enter the time (eg, 7:00, 7:10, etc) in the left hand column, and the corresponding traffic volume in the right hand column.
7	Average time period traffic intensity	Calculate the average time period traffic intensity (number of vehicles per x minutes) by summing the traffic volumes in **(6)** and dividing by the number of time intervals in the time period **(5)**.
8	Peak interval start	Calculate the start of the peak interval as follows: Search down the traffic volumes by interval **(6)** and find the first interval where the volume which exceeds the average intensity **(7)**, and then identify the previous interval time and traffic volume. Calculate the time in the interval where the traffic volume will exceed the average: subtract the traffic volume of the previous interval identified in (a) from the average intensity **(7)**. Divide the result by the difference between the traffic volumes in (a) and the next time interval, and then multiply by the length of the time interval; and add this time to the previous interval time determined in (a).
9	Peak interval end	Calculate the end of the peak interval in a similar manner to **(8)** above, except the search is for the first interval where the traffic volume drops below the average intensity **(7)**.
10	Length of peak interval	Calculate the length of the peak interval (in minutes) by subtracting the peak interval start time **(8)** from the end time **(9)**. See appendix A3.15.
11	Peak interval traffic volume	Calculate the traffic volume in the peak interval by summing the volume of vehicles in each interval. Where the peak interval is part of a time interval, take the proportion of traffic that falls within the peak interval. See example calculation in appendix A3.16
12	Peak interval traffic intensity	Calculate the peak interval traffic intensity (in vehicles /hour) by dividing the peak interval traffic volume **(11)** by the length of the peak interval **(10)**. See example calculation in appendix A3.16

Worksheets A3: Travel time estimation, continued

Peak interval traffic for a given time period **Worksheet A3.1**

1 Project option (do minimum or option)

2 Road section/movement

3 Time period

4 Length of time interval (in minutes)

5 Number of intervals in time period

6 **Traffic volumes by interval**

Interval time	**Traffic volume**
Total traffic volume in all intervals:	

7 Average time period traffic intensity (vehicles per interval of x minutes)

8 Peak interval start time

9 Peak interval end time

10 Length of peak interval (minutes) **(9)** – **(8)**

11 Peak interval traffic volume (vehicles)

12 Peak interval traffic intensity (vehicles/hour)

Worksheets A3: Travel time estimation, continued

Explanation sheet for motorway travel time **Worksheet A3.2**

This worksheet is used to calculate the motorway travel time. Note that worksheet A3.2 and A3.5 will need to be completed simultaneously in order to calculate the 'time period total average travel time', which is the final step of worksheet A3.2.

1	Project option	Enter the project option (eg, do minimum, option A, etc)
2	Road section/movement	Enter the road section or movement identifying number from worksheet A2.1.
3	Time period	Enter the time period (eg, AM peak [7-9 am], PM peak [4-6 pm).
4	Section length	Enter the section length in kilometres.
5	Design speed	Enter the design speed for the motorway.
6	Number of lanes	Enter the number of through lanes in the direction of travel.
7	Proportion of trucks	Enter the proportion of trucks (HCVI and HCVII) in the traffic stream during the peak period.
8	Terrain type	Enter the terrain type: level, rolling or mountainous.
9	Free speed	Enter the free speed from worksheet A2.8 or the default speed from appendix A3.4.
10	Free speed travel time	If necessary, convert the free speed travel time from km/h to minutes per kilometre by dividing **(9)** by 60.
11	Basic capacity	Enter the basic motorway capacity in pcu/hour from appendix A3.9.
12	Truck passenger car equivalent	Based on the terrain type, enter the passenger car unit equivalent factor for trucks from appendix A3.9.
13	Truck adjustment factor	Calculate the truck adjustment from the formula in appendix A3.9.
14	Capacity	Calculate the capacity (in vehicles/hour) by multiplying the basic capacity **(11)** by the truck adjustment factor **(13)**.
15	Volume to capacity ratio	Determine the volume to capacity ratio (VC ratio) by dividing the peak traffic intensity from worksheet A3.1 by the capacity **(14)**. Refer appendix A3.17.
16	Peak interval additional travel time factor	Based on the VC ratio, determine the appropriate factor from appendix A3.18.
17	Time period additional travel time	Calculate the time period additional travel time (in minutes per kilometre) by multiplying the free speed travel time **(10)** by the peak interval additional travel time factor **(16)**. Refer to appendix A3.18.
18	Bottleneck delay	If the VC ratio ≥1.0 at any time during the time period, calculate the bottleneck delay in minutes from worksheet A3.5 and enter here. Refer to appendix A3.19 for further explanation.
19	Speed change cycle travel time	If required, determine the additional travel time required for any speed change cycles for the road section/movement using worksheet A3.6 and enter here. Appendix A3.21 provides further guidance.
20	Time period total average travel time	Calculate the time period total average travel time in minutes by multiplying the free speed travel time **(10)** plus the peak interval **(16)** and time period additional travel time **(17)** by the section length **(4)** and then adding the bottleneck delay **(18)** and the speed change cycle travel time **(19)**. Refer to appendix A3.22.

Worksheets A3: Travel time estimation, continued

Motorway travel time **Worksheet A3.2**

1	Project option (do minimum or option)			
2	Road section/movement			
3	Time period			
4	Section length	Worksheet A2.1		km

	Characteristic of motorway section	Reference		
5	Design speed			km/h
6	Number of through lanes			
7	Proportion of trucks			
8	Terrain type			
9	Free speed	Appendix A3.4		km/h
10	Free speed travel time **(9)**/60			min/km
11	Basic capacity	Appendix A3.9		pcu/h
12	PCU equivalent for trucks	Appendix A3.9		
13	Truck adjustment factor	Appendix A3.9		

14	Capacity **(11)** x **(13)**			veh/h
15	Volume to capacity ratio	Appendix A3.17		
16	Peak interval additional travel time	Appendix A3.18		min/km
17	Time period additional travel time	Appendix A3.18		min/km
18	Bottleneck delay	Worksheet A3.5		min
19	Speed change cycle travel time	Worksheet A3.6		min
20	Time period total average travel time	Appendix A3.22		min

(4) × [**(10)** + **(16)** + **(17)**] + **(18)** + **(19)**

Worksheets A3: Travel time estimation, continued

Explanation sheet for multilane road travel time **Worksheet A3.3**

This worksheet is used to calculate the travel time on multilane roads. Note that worksheet A3.3 and A3.5 will need to be completed simultaneously in order to calculate the 'time period total average travel time', which is the final step of worksheet A3.3.

1	Project option	Enter the project option (eg, do minimum, option A, etc)
2	Road section/movement	Enter the road section or movement identifying number from worksheet A2.1.
3	Time period	Enter the time period (eg, AM peak [7-9 am], PM peak [4-6 pm]).
4	Section length	Enter the section length in kilometres.
5	Posted speed limit	Enter the speed limit in kilometres per hour.
6	Basic free speed	Enter the basic free speed as determined from appendix A3.5
7	Dividing median present?	Circle 'Yes' or 'No' to indicate if a physical median is present. Enter the appropriate speed reduction factor (in km/h) from appendix A3.5.
8	Lane width	Enter the lane width in metres. Enter the appropriate speed reduction factor (in km/h) from appendix A3.5.
9	Lateral clearance	Enter the lateral clearance in accordance with appendix A3.5. Enter the appropriate speed reduction factor (in km/h) from appendix A3.5.
10	Number of access points per km	Enter the number of access points per kilometre. Enter the appropriate speed reduction factor (in km/h) from appendix A3.5.
11	Sum of the basic free speed reductions	Calculate the sum of the basic free speed reductions by adding **(7)**, **(8)**, **(9)**, and **(10)** together.
12	Adjusted free speed	Calculate the free speed (in km/h) as the basic free speed **(6)** less the sum of the basic free speed reductions **(11)**.
13	Free speed travel time	Calculate the free speed travel time in minutes per kilometre by dividing 60 by **(12)**.
14	Capacity	Based on the sum of basic free speed reductions **(11)**, determine the capacity in vehicles/hour/lane from appendix A3.10.
15	Volume to capacity ratio	Determine the volume to capacity ratio (VC ratio) by dividing the peak traffic intensity from worksheet A3.1 by the capacity **(14)**. Refer appendix A3.17.
16	Peak interval additional travel time	Based on the VC ratio, determine the appropriate factor from appendix A3.18.
17	Time period additional travel time	Calculate the time period additional travel time (in minutes per kilometre) by multiplying the free speed travel time **(13)** by the peak interval additional travel time factor **(16)**.
18	Bottleneck delay	If the VC ratio ≥1.0 at any time during the time period, calculate the bottleneck delay in minutes from worksheet A3.5. Refer appendix A3.19.
19	Speed change cycle travel time	If necessary (see appendix A3.21), determine the additional travel time required for any speed change cycles for the road section/movement using worksheet A3.6 and enter here.
20	Time period total average travel time	Calculate the time period total average travel time in minutes by multiplying the free speed travel time **(13)** plus the peak interval **(16)** and time period additional travel time **(17)** by the section length **(4)** and then add the bottleneck delay **(18)** and the speed change cycle travel time **(19)**. Refer to appendix A3.22.

Worksheets A3: Travel time estimation, continued

Multilane roads travel time **Worksheet A3.3**

1	Project option (do minimum or option)		
2	Road section/movement		
3	Time period		
4	Section length		m
5	Posted speed limit (km/h)		km/h

	Characteristics of a multilane road	**Appendix A3.5**			
6	Basic free speed				km/h
				Reduction	
7	Dividing median present?		Yes / no		km/h
8	Lane width		metres		km/h
9	Lateral clearance		metres		km/h
10	Number of access points per km		per km		km/h
11	Sum of basic free speed reductions **(7)** + **(8)** + **(9)** + **(10)**				km/h

12	Adjusted free speed **(6)** - **(11)**			km/h
13	Free speed travel time 60/**(12)**			min/km
14	Capacity	Appendix A3.10		veh/hour/lane
15	Volume to capacity ratio	Appendix A3.17		
16	Peak interval additional travel time	Appendix A3.18		min/km
17	Time period additional travel time	Appendix A3.18		min/km
18	Bottleneck delay	Worksheet A3.5		mins
19	Speed change cycle travel time	Worksheet A3.6		mins
20	Time period total average travel time	Appendix A3.22		mins
	(4) × [**(13)** + **(16)** + **(17)**] + **(18)** + **(19)**			

Worksheets A3: Travel time estimation, continued

Explanation sheet for two-lane rural road free speed **Worksheet A3.4(a)**

This worksheet is used to determine the free speed and free speed travel time for two-lane rural roads. The capacity and time period total average travel time are calculated using worksheet A3.4(a). Appendix A3.6 provides guidance.

For multilane rural roads, worksheet A3.3 should be used to determine the free speed, free speed travel time and time period total average travel time.

1	Project option	Enter the project option (eg, do minimum, option A, etc)
2	Road section/movement	Enter the road section or movement identifying number from worksheet A2.1.
3	Description of section	Where applicable, indicate whether the road section is a straight/tangent or curve
4	Section length	Enter the section length in kilometres.
5	Design speed	Enter the design speed of the road section/movement in km/h. In the case of a curve, enter the design speed as per the project plan or diagrams. For straights/tangents, use the default speeds from appendix A3.6.
6	Travel time at design speed	Calculate the travel time at the design speed in minutes by dividing the length **(4)** by the design speed **(5)** and multiplying by 60.
7	Total length	Calculate the total length for the road by summing column **(4)**.
8	Total travel time	Calculate the total travel time (in minutes) by summing column **(6)**.
9	Average design speed	Calculate the average design speed in kilometres/hour by dividing the total length **(7)** by the total travel time **(8)** and multiplying by 60.
10	Free speed	Determine the free speed (in km/h), based on the average design speed, as given in appendix A3.6.
11	Free speed travel time	Calculate the free speed travel time (in minutes per kilometre) by dividing 60 by the free speed **(10)**.

Worksheets A3: Travel time estimation, continued

Two-lane rural road free speed **Worksheet A3.4(a)**

1 Project option (do minimum or option) _____

Road section/ movement (2)	Description of road section (3)	Section length (4)	Design speed (5)	Travel time at design speed (mins) (6) = 60 x (4)/(5)

7 Total length (sum of column **(4)**, km) _____

8 Total travel time (sum of column **(6)**, min) _____

9 Average design speed **(7)**/**(8)** x 60 _____ km/h

10 Free speed Appendix A3.6 _____ km/h

11 Free speed travel time 60/**(10)** _____ mins/km

Worksheets A3: Travel time estimation, continued

Explanation sheet for two-lane rural road travel time **Worksheet A3.4(b)**

This worksheet is used to calculate the capacity and time period total average travel time on two-lane rural roads. Appendix A3.11 provides guidance. In the first instance, the ideal capacity of 2,800 vehicles/hour is adjusted to account for a number of factors.

1	Project option	Enter the project option (eg, do minimum, option A, etc)
2	Road section/movement	Enter the road section or movement identifying number from worksheet A2.1.
3	Time period	Enter the time period (eg, AM peak [7-9 am], PM peak [4-6 pm]).
4	Section length	Enter the section length from worksheet A3.4(a).
5	Total traffic volume in time period	Enter the total traffic volume for the time period under consideration
6	percentage of traffic in peak direction	Enter the percentage of the total traffic volume for the time period travelling in the peak direction
7	Free speed travel time	Enter the free speed travel time from worksheet A3.4(a).
8	Directional distribution adjustment factor	Enter the directional ratio, being the ratio of the volume of traffic in the peak direction to the total traffic volume. Enter the adjustment factor from appendix A3.11.
9	Total roadway width adjustment factor	Enter the total roadway width which includes the lane width(s) plus the sealed shoulder width(s). Enter the adjustment factor from appendix A3.11.
10	PCU equivalent for trucks (based on terrain type)	Determine the passenger car unit equivalent factor for trucks from appendix A3.11 based on the terrain type (level, rolling, mountainous).
11	Proportion of trucks	Enter the proportion (as a decimal) of trucks in the traffic stream.
12	Truck adjustment factor	Calculate the truck adjustment factor from the formula $1/[1 + \mathbf{(4)} \times \{\mathbf{(10)} - 1\}]$ as presented in appendix A3.11.
13	Capacity	Calculate the capacity (in vehicles/hour) from the formula $2800 \times \mathbf{(8)} \times \mathbf{(9)} \times \mathbf{(11)}$.
14	Capacity of traffic in peak direction	Calculate the peak direction capacity (in vehicles/hour) as the capacity **(13)** multiplied by the proportion of traffic in peak direction **(6)**.
15	Volume to capacity ratio	Determine the volume to capacity ratio (VC ratio) by dividing the peak traffic intensity from worksheet A3.1 by the capacity **(13)**. Refer appendix A3.17.
16	Percentage of no passing	Enter the percentage of road length for which there is no passing.
17	Peak interval additional travel time	Based on the VC ratio, the percentage of no passing, and the terrain type, determine the appropriate factor from appendix A3.18.
18	Time period additional travel time	Calculate the time period additional travel time (in minutes per kilometre) by multiplying the free speed travel time **(7)** by the peak interval additional travel time factor **(17)**.
19	Bottleneck delay	If the VC ratio ≥1.0 at any time during the time period, calculate the bottleneck delay in minutes from worksheet A3.5 and enter here. Refer appendix A3.19.
20	Speed change cycle travel time	If necessary (see appendix A3.21), determine the additional travel time required for any speed change cycles for the road section/movement using worksheet A3.6 and enter here.
21	Time period total average travel time	Calculate the time period total average travel time in minutes by multiplying the free speed travel time **(7)** plus the peak interval **(17)** and time period additional travel time **(18)** by the section length **(4)** and then adding the bottleneck delay **(19)** and the speed change cycle travel time **(20)**. Refer to appendix A3.22.

Worksheets A3: Travel time estimation, continued

Two-lane rural road travel time **Worksheet A3.4(b)**

1	Project option (do minimum or option)			
2	Road section			
3	Time period			
4	Section length			km
5	Total traffic volume in time period	Worksheet A3.4(a)		
6	Proportion of traffic in peak direction			%
7	Free speed travel time	Worksheet A3.4(a)		min/km

	Characteristic of rural road (Appendix A3.11)			**Adjustment**	
8	Directional distribution ratio	/			
9	Total roadway width		metres		
10	PCU equivalent for trucks (based on terrain)	Level/rolling/ mountainous			pcu
11	Proportion of trucks				%
12	Truck adjustment factor 1/[1 + **(11)** x {**(10)** – 1}]				
13	Capacity 2800 x **(8)** x **(9)** x **(12)**				veh/h

14	Capacity of traffic in peak direction **(13)** x **(6)**			veh/h
15	Volume to capacity ratio	Appendix A3.17		
16	Percentage of no passing			%
17	Peak interval additional travel time factor	Appendix A3.18		min/km
18	Time period additional travel time	Appendix A3.18		min/km
19	Bottleneck delay	Worksheet A3.5		secs
20	Speed change cycle travel time	Worksheet A3.6		mins
21	Time period total average travel time	Appendix A3.22		mins

Worksheets A3: Travel time estimation, continued

Explanation sheet for calculating the bottleneck delay **Worksheet A3.5**

This worksheet is used to calculate the bottleneck delay for all time periods during which demand exceeds capacity (volume to capacity ratio ≥1.0). For further guidance and an example of the calculations, refer appendix A3.19.

1	Project option	Enter the project option (eg, do minimum, option A, etc)
2	Road section/movement	Enter the road section or movement identifying number from worksheet A2.1.
3	Time period	Enter the time period (eg, AM peak [7-9 am], PM peak [4-6 pm).
4	Length of time interval	Enter the length of the time interval in minutes. This will usually be 5, 10 or 15 minutes.
5	Interval capacity (vehicles/interval)	The interval capacity is calculated by taking the total capacity (vehicles per hour) from worksheet A3.2, A3.3 or A3.4 as appropriate and dividing it by the number of intervals per hour
6	Interval start time	Enter the interval start time (eg, 7:00, 7:10, etc).
7	Demand	Enter the traffic volume (vehicle count) for the time interval.
8	Cumulative demand	Calculate the cumulative volume for the time period by adding the traffic volume for the current interval to the cumulative total from the previous interval.
9	Vehicles discharged	Enter the number of vehicles moving through (exiting) the section /movement during the interval. Note that during one or more intervals, the number of vehicles discharged in the interval will be equivalent to the 'time period interval capacity' (maximum number of vehicles per interval) of the road section/movement.
10	Cumulative discharge	Calculate the cumulative volume of vehicles discharged from the section/movement for the time period by adding the volume discharged for the current interval to the cumulative total from the previous interval.
11	Queue at end of interval	Calculate the number of vehicles remaining in the queue at the end of the interval by subtracting the cumulative total of vehicles discharged **(10)** from the cumulative volume **(8)**.
12	Queue at start of interval	Enter the number of vehicles in the queue at the start of the interval. This is equivalent to the number of vehicles remaining in the queue at the end of the *previous* interval **(11)**.
13	Average delay	Calculate the average delay (in vehicle minutes) by adding together the number of vehicles in queue at start of interval **(12)** and the number of vehicles remaining in queue at end of interval **(11)** and dividing this total by 2. Multiply this result by the length of the time interval **(4)**.
14	Time period total delay	The time period total delay (in vehicle minutes) is determined by adding together the values for the average delay per interval.
15	Time period average delay per vehicle	The time period average delay per vehicle (in minutes per vehicle) is calculated by dividing the time period total delay **(14)** by the *final* cumulative total volume of vehicles discharged **(10)**.

Worksheets A3: Travel time estimation, continued

Calculating the bottleneck delay **Worksheet A3.5**

1 Project option (do minimum or option)

2 Road section/movement

3 Time period

4 Length of time interval (in minutes)

5 Capacity (vehicles/interval)

Interval start time (6)	Demand (vehicles) (7)	Cumulative demand (vehicles) (8)	Vehicles discharged (vehicles) (9)	Cumulative discharge (vehicles) (10)	Queue at end of interval (11)	Queue at start of interval (12) = (8) – (10)	Average delay (veh-min) (13) = [(11) + (12)]/2 × (4)

14 Time period total delay = sum of average delay per interval **(13)**

15 Time period average delay per vehicle (minutes/vehicle)

= **(14)**/final cumulative total volume of vehicles discharged **(10)**

Worksheets A3: Travel time estimation, continued

Explanation sheet for speed change cycle additional travel time **Worksheet A3.6**

If vehicles are required to slow to negotiate some isolated feature and then accelerate back to cruise speed, this worksheet is used to calculate the additional travel time for the speed change cycle (SCC). Where the initial cruise speed and the final speed are available, appendix A5.7 provides the additional travel time in seconds for speed change cycles. For further guidance and an example of the calculations, refer appendix A3.21.

1	Project option	Enter the project option (eg, do minimum, option A, etc)
2	Road section/movement	Enter the road section or movement identifying number from worksheet A2.1.
3	Length of SCC section	Enter the length of SCC section which is where vehicles are required to slow to negotiate some isolated feature and then accelerate back to cruise speed. It may be a sub-section of the section identified in **(2)**.
4	Free speed	Enter the free speed as determined from worksheet A3.2, A3.3 or A3.4(a) depending on the road type.
5	Curve radius	Enter the horizontal curve radius (in metres)
6	Free speed travel time for the SCC section	Enter the free speed travel time (in minutes/km) as determined from worksheet A3.2, A3.3 or A3.4(a) depending on the road type. Divide this by the length of the speed cycle change section **(3)** to obtain the free speed travel time for the SCC section.
7	Time period additional travel time for the SCC section	Enter the time period additional travel time per vehicle (in minutes) as determined from worksheet A3.2, A3.3 or A3.4(a) depending on the road type. Divide this by the length of the speed cycle change section **(3)** to obtain the time period additional travel time for the section.
8	Ideal speed for each vehicle type	Calculate the ideal vehicle speed for each relevant vehicle type using the formula provided and the free speed **(4)** and curve radius **(5)**.
9	Operating speed for SCC	Using the formula provided, calculate the operating speed for the SCC section.
10	Speed change cycle travel time by vehicle type	Based on the operating speed for each vehicle type **(9)**, their ideal speed for negotiating the SCC section, select the additional travel time in seconds from appendix A5, tables A5.24, A5.26, A5.28, A5.30, A5.32, A5.34. Note that the 'initial speed' in the table is the operating speed and the 'final speed' is the ideal speed.
11	Speed change cycle travel time for SCC section	Sum the values for each vehicle type to get the total speed change cycle travel time for the SCC section. Enter this value in the appropriate worksheet A3.2, A3.3 or A3.4(a) depending on the road type.

Worksheets A3: Travel time estimation, continued

Speed change cycle additional travel time **Worksheet A3.6**

1 Project option _____

2 Road section/movement _____

3 Length of speed change cycle (SCC) section _____ metres

4 Free speed _____ km/h

5 Curve radius _____ metres

6 Free speed travel time (FSTT) for the SCC section _____ min/km

= FSTT for whole section (from earlier worksheets) × **(3)**

7 Time period additional travel time (TPATT) for the SCC section _____ min/km

= TPATT for whole section (from earlier worksheets) × **(3)**

Vehicle type	**f_1 x a_1**	**a_0**	**a_2**	**Ideal travel speed (km/h)** **(f_1 x a_1) x (4) + a_0 + a_2/(6)** **(8)**	**Operating speed for speed change cycle (km/h)** **60/[(6)+(7)]** **(9)**	**Speed change cycle travel time by vehicle type** **(appendix A5)** **(10)**
Car	0.5833	45.21	-3892			
LCV	0.4395	54.51	-3337			
MCV	0.4222	51.77	-3245			
HCV I	0.3702	59.16	-3506			
HCV II	0.2807	69.57	-3768			
Bus	0.3702	59.16	-3506			

11 Speed change cycle travel time for speed change cycle section _____

= sum of speed change cycle travel time by vehicle type **(10)**

Worksheets A3: Travel time estimation, continued

Explanation sheet for other urban road travel time **Worksheet A3.7**

This worksheet is used to calculate the travel time on other urban roads. It is possible to use one worksheet per project option.

1	Project option	Enter the project option (eg, do minimum, option A, etc)
2	Road section/movement	Enter the road section or movement identifying number from worksheet A2.1.
3	Time period	Enter the time period (eg, AM peak [7-9 am], PM peak [4-6 pm).
4	Section length	Enter the section length in kilometres.
5	Design category	Enter the design category from appendix A3.7.
6	Functional category	Enter the functional category from appendix A3.7.
7	Road classification	Enter the road classification from appendix A3.7.
8	Free speed	Enter the free speed from appendix A3.7.
9	Free speed travel time	Calculate the free speed travel time for the section (in minutes/km) by multiplying the free speed **(8)** by the section length **(4)** and dividing this by 60.

Worksheets A3: Travel time estimation, continued

Other urban road travel time **Worksheet A3.7**

1 Project option _____

2 Time period _____

Road section /movement (3)	Section length (4)	Design category (5)	Function category (6)	Road classification (7)	Free speed (km/h) (8)	Free speed travel time (mins) (8)/60 × (4) (9)

Worksheets A3: Travel time estimation, continued

Explanation sheet for traffic signal travel time **Worksheet A3.8**

With respect to intersections, travel time is measured using delay. This worksheet is used to calculate or report on the delays at a signalised intersection. The primary calculation for delay generally involves the use of some type of transport model or intersection software. Further information is provided in appendix A3.23.

The ideal saturation flow rate is given as 2000 passenger car units per hour of green. This is modified according to the worksheet adjustment factors as indicated.

1	Project option	Enter the project option (eg, do minimum, option A, etc)
2	Road section/movement	Enter the road section or movement identifying number from worksheet A2.1.
3	Time period	Enter the time period (eg, AM peak [7-9 am], PM peak [4-6 pm).
4	Approach	Enter the approach number. An approach is a lane or 'arm' feeding into the intersection.
5	Lane width	Enter the lane width in metres.
6	Number of lanes	Enter the number of lanes at the stop line.
7	Approach grade	Enter the approach grade in percent.
8	Parking manoeuvres	Enter the number of parking manoeuvres per hour within 50 metres on either side of the intersection.
9	Locality type	Enter the locality type consistent with appendix A3.23, table A3.4.
10	Signal type	Enter the signal type consistent with appendix A3.23, table A3.6.
11	Lane width factor	Enter the lane width factor from appendix A3.23, table A3.1.
12	Approach grade factor	Enter the approach grade factor from appendix A3.23, table A3.2.
13	Parking factor	Enter the parking factor from appendix A3.23, table A3.3.
14	Locality factor	Enter the locality factor from appendix A3.23, table A3.4.
15	Saturation flow rate	Calculate the saturation flow rate (pcu/hour) from the formula provided.
16	Arrival type	Determine the arrival type from appendix A3.23, table A3.5.
17	Delay adjustment factor	Determine the delay adjustment factor from appendix A3.23, table A3.6 for the saturation ratio **(15)** and arrival type **(16)**.
18	Time period total average travel time	Calculate the total delays for each of the movements in minutes using appropriate transport model or intersection software.
19	Total time period delay	Calculate the total time period delay by summing the time period total average travel time **(18)** for all approaches into the intersection. This may be generated by a transportation model.
20	Traffic volume	Enter the traffic volume (number of vehicles entering the intersection during the time period).
21	Average movement delay	Calculate the average delay per vehicle by dividing the total time period delay **(19)** by the traffic volume **(20)**.

Worksheets A3: Travel time estimation, continued

Traffic signal delay **Worksheet A3.8**

1 Project option (do minimum or option) _____

2 Road section/movement _____

3 Time period _____

4	Approach						
5	Lane width						
6	Number of lanes						
7	Approach grade						
8	Parking manoeuvres						
9	Locality type						
10	Signal type						
11	Lane width factor						
12	Approach grade factor						
13	Parking factor						
14	Locality factor						
15	Saturation flow rate 2000 x **(11)** x **(12)** x **(13)** x **(14)**						
16	Arrival type						
17	Delay adjustment factor						
18	Time period average delay						

19 Total time period delay (sum **(18)** for all approaches) _____ minutes

20 Traffic volume for the intersection _____ vehicles per time period

21 Average delay per vehicle **(19)**/**(20)** _____ minutes per vehicle

Worksheets A3: Travel time estimation, continued

Explanation sheet for priority intersection and roundabout delay **Worksheet A3.9**

This worksheet is used to calculate the delays at priority intersections and/or roundabouts. It is expected that the primary calculations for capacity and/or delay generally involve the use of some type of transport model or intersection software, particularly in the case of roundabouts. Further guidance is provided in appendix A3.24 and A3.25. **Steps (7) through (17) only apply to movements and controls within priority level (b) and (c) approaches.**

1	Project option	Enter the project option (eg, do minimum, option A, etc)
2	Road section/movement	Enter the road section or movement identifying number from worksheet A2.1.
3	Time period	Enter the time period (eg, AM peak [7-9 am], PM peak [4-6 pm]).
4	Approach	Enter the approach number. An approach is a lane or 'arm' feeding into the intersection. If there are more than 3 approaches, two worksheets may be required.
5	Priority level	Determine the priority level of the approach in accordance with appendix A3.24. **Only priority levels b and c experience delay.**
6	Movement and control	Enter the movement and control for the analysis. Refer appendix A3.24, table A3.8.
7	Average speed	Enter the average speed (km/h) for the movement and control – either <60 or ≥60 km/h)
8	Conflicting traffic volume during peak interval	Enter the conflicting traffic volume during the peak interval in vehicles/hour.
9	Critical gap	Select the critical gap from appendix A3.24, table A3.8.
10	Minimum headway in conflicting flow	Enter the minimum head in conflicting flow as either 2.0 (where there is a single lane conflict) or 0.5 seconds (in all other cases).
11	Follow up headway	Using the formula provided, calculate the follow up headway based on the critical gap **(9)**.
12	Capacity	Calculate the capacity of the movement and control as a function of the minimum headway in conflicting flow, the critical gap, follow-up headway and conflicting volume during peak interval.
13	Volume to capacity ratio	Calculate the VC ratio by dividing the traffic volume **(8)** by the capacity **(12)**, up to a maximum VC ratio of 1.05 for any approach.
14	Peak interval average travel time	Based on the VC ratio, select the time period total average travel time (in minutes/vehicle) for the movement and control, which is taken as being equal to the average peak interval delay, from appendix A3.24, table A3.9.
15	Total time period average travel time for the intersection	Calculate the total peak interval delay for the intersection by summing the time period total average travel time **(14)** for all movements and controls from all approaches into the intersection.
16	Traffic volume	Enter the total traffic volume (number of vehicles) entering the intersection during the time period.
17	Average delay per vehicle	Calculate the average movement delay by dividing the total time period average travel time for the intersection **(15)** by the traffic volume **(16)**.

Worksheets A3: Travel time estimation, continued

Priority intersection and roundabout delay **Worksheet A3.9**

1 Project option (do minimum or option) _____

2 Road section/movement _____

3 Time period _____

4	Approach									
5	Priority									
6	Movement and control									
7	Average speed (<60 or ≥60 km/h)									
8	Conflicting traffic volume during peak interval									
9	Critical gap									
10	Minimum headway in conflicting flow (either 2.0 secs or 0.5 secs)									
11	Follow up headway 0.2 × **(9)** + 2.0									
12	Capacity (veh/h) [3600/**(11)**] × exp[-**(8)** × **(9)**/3600]									
13	Volume to capacity ratio **(8)**/**(12)**									
14	Peak interval average travel time									

15 Total time period average travel time for the section (sum of **(14)** for all approaches) _____ minutes

16 Traffic volume for the intersection _____ vehicles per time period

17 Average delay per vehicle **(15)**/**(16)** _____ minutes per vehicle

Worksheets A4: Travel time cost savings

Explanation sheet for travel time cost savings **Worksheet A4.1**

This worksheet is used to calculate travel time costs.

1	Project option	Enter the project option (eg, do minimum, option A, etc)
2	Road section/movement	Enter the road section or movement identifying number from worksheet A2.1.
3	Time period	Enter the time period (eg, AM peak [7-9 am], PM peak [4-6 pm).
4	Time periods per year	Enter the number of time periods per year.
5	Road category	Enter the road category consistent with appendix A2.2.
6	Vehicles per time period	Enter the number of vehicles for the vehicle class in the time period from worksheet A2.7.
7	Total travel time	Enter the total travel time from the appropriate worksheet A3.2 through A3.8.
8	Travel time cost	Determine the travel time cost from appendix A4, table A4.3 (or tables A4.1 and A4.2 for non-standard vehicle composition percentages).
9	Congestion cost	Determine the additional value for congestion from appendix A4.4.
10	Trip time reliability	Determine the additional value of trip time reliability from appendix A4.5. Note: Change in trip time reliability applies only to the option(s).
11	Total cost per year	Calculate the total cost per year according to the following formula: **(11)** = **(4)** × **(6)** × **(7)** × (**(8)** + **(9)**) / 60 + (**(4)** × **(10)**)

Worksheets A4: Travel time cost savings, continued

Travel time cost savings **Worksheet A4.1**

Option (1)	Road section/ movement (2)	Time period (3)	Time periods per year (4)	Road category (5)	Vehicles per time period (6)	Total travel time (min) (7)	Travel time cost ($/hour) (8)	Congestion cost ($/hour) (9)	Trip time reliability cost ($/period) (10)	Total cost/year ($) (11)

Worksheets A5: Vehicle operating cost savings

Explanation sheet for unit vehicle operating costs **Worksheet A5.1**

This worksheet is used to compute unit vehicle operating costs (ie, operating costs per vehicle). The output of this worksheet is used as input to Worksheet A5.2. If there are only a few road sections/intersections and a few time periods to be analysed, it may be possible to accommodate all project options on one sheet.

1	Project option	Enter the project option.
2	Road section/movement	Enter the road section/movement number from worksheet A2.1.
3	Section length	Enter the length of the road section/movement.
4	Gradient	Enter the gradient of the road section/movement in percent from worksheet A2.1.
5	Road roughness	Enter the road roughness for the road section from worksheet A2.1, or if the road section has not been maintained or graded in accordance with normal maintenance procedures, except for rehabilitation projects, enter the road roughness which would pertain.
6	Vehicle type	Enter one of the standard vehicle classifications described in appendix A2, eg, car, LCV, etc. Alternatively, if the traffic vehicle composition is to be assumed to be typical of one of the standard road traffic classifications described in appendix A2, then enter the classification eg, rural strategic, etc.
7	Section speed	Enter the average cruise speed.
8	Volume/capacity ratio	Enter the volume/capacity ratio as determined in appendix A3.17.
9	Base cost	Determine the base cost from appendix A5, tables A5.1 to A5.11 The inputs are section speed **(7)** and average gradient from **(4)**. The output is base operating cost in cents per kilometre.
10	Pavement related cost	Determine the total pavement related costs, ie, the sum of roughness costs, road surface texture costs and pavement elastic deflection costs (appendix A5.3).
11	Congestion related cost	Determine the additional vehicle operating costs due to congestion (appendix A5.4).
12	Speed changes and stops	Enter the lowest speed reached during the speed change cycle. For stops enter 0 or stop.
13	Additional cost	Determine the additional cost for a speed change or stop from appendix A5.6. If there are several speed changes or stops in a section, the total additional cost of these is determined.
14	Queuing delay	Enter the time spent idling or creeping forward in congested conditions from worksheet A2.8. This does not include geometric delay which is allowed for by speed changes and stops.
15	Fuel cost	Calculate the cost of fuel used while queuing by multiplying the queuing delay **(14)** by the unit cost in appendix A5.5, table A5.22 or A5.23.
16	Section unit cost	Calculate the unit cost for the section using the formula: **(16)** = ((**(9)** + **(10)** + **(11)**) × **(3)**/1000) + **(13)** + **(15)**

Worksheets A5: Vehicle operating cost savings, continued

Unit vehicle operating costs - EXAMPLE **Worksheet A5.1**

Time period _____

Option	Section/ movement	Section length (m)	Average gradient (%)	Surface roughness (IRI)	Vehicle type	Section speed	VC ratio	Base cost (cents/km)	Pavement related cost (cents/km)	Congestion related cost (cents/km)	Speed changes and stops		Queuing delay		Section cost (cents)
											Min speed (km/h)	Addit. cost (cents)	Time (mins)	Fuel (cents)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Example 1: Urban T intersection															
Do min	1	500	0	3.5	All UA	50		17.2	0.4		-	-	-	-	8.8
	2	500	0	3.5	All UA	50		17.2	0.4		-	-	-	-	8.8
	3	550	0	3.5	All UA	50		17.2	0.4		10	0.7	-	-	10.4
	4	550	0	3.5	All UA	50		17.2	0.4		0	0.8	0.2	0.23	10.7
	5	550	0	3.5	All UA	50		17.2	0.4		0	0.8	2.2	2.55	13.0
	6	550	0	3.5	All UA	50		17.2	0.4		0	0.8	4.5	5.21	15.7
Example 2: Rural road realignment															
A	1	530	+5	3.0	All RO	80	0.55	21.1	0.1	0.8	60	0.8	-	-	12.5
B	1	450	+6	3.0	All RO	75	0.50	21.5	0.1	0.5	-	-	-	-	9.9

Worksheets A5: Vehicle operating cost savings, continued

Explanation sheet for vehicle operating cost savings **Worksheets A5.2**

This worksheet is used to compute vehicle operating costs using the unit costs determined in Worksheet A5.1. If the project is small it may be possible to accommodate all project options on one sheet.

1	Project option	Enter the project option.
2	Section/movement number	Enter the road section/movement number from worksheet A2.1.
3	Time units	Specify the time units to be used in the calculations, eg, hours, days or years.
4	Period	Enter the time periods under consideration.
5	Time periods per year	Calculate the time periods per year in the period specified in **(4)**. For instance if time periods are hours and period is 7 am – 9 am on workdays the time periods per year is 2 (hours per period) × 245 (workdays per year) = 490.
6	Vehicle type	Enter the vehicle types as determined under **(6)** in worksheet A5.1.
7	Vehicles per time period	Enter the vehicles per time period from **(6)** in worksheet A4.1. Include decimal fractions of a vehicle if dealing with low volumes as these can have a significant influence on the total cost.
8	Section cost	Enter the section unit cost from **(16)** in worksheet A5.1.
9	Total cost per year	Calculate the total cost per year for the section using the formula: **(9)** = **(5)** × **(7)** × **(8)** / 100

Worksheets A5: Vehicle operating cost savings, continued

Vehicle operating cost savings - EXAMPLE **Worksheets A5.2**

Time period _____

Option (1)	Section/ movement (2)	Time units (3)	Period (4)	Time units per year (5)	Vehicle type (6)	Vehicles per time unit (7)	Section cost (cents) (8)	Total cost per year ($) (9)
Example 1								
Do min	1	hours	Weekdays 7.30-9.30	490	All UA	3650	8.8	0
	2	hours	Weekdays 7.30-9.30	490	All UA	2500	8.8	157,388
	3	hours	Weekdays 7.30-9.30	490	All UA	330	10.4	107,800
	4	hours	Weekdays 7.30-9.30	490	All UA	210	10.7	16,817
	5	hours	Weekdays 7.30-9.30	490	All UA	360	13.0	11,010
	6	hours	Weekdays 7.30-9.30	490	All UA	240	15.7	22,932
								315,947
Example 2								
A	1	days	All	365	All RO	2210	12.5	0
B	1	days	All	365	All RO	2210	9.9	79,858

Worksheets A6: Accident cost savings

Explanation for worksheet A6.2 **Accident by accident analysis - do minimum**

There must be 5 years or more accident data for the site and the number and types of accidents must meet the specifications set out in appendix A6.1 and A6.2.

1. Enter number of years of typical accident rate records at **(3)** and the number of reported accidents in the reporting period for each of the severity categories at **(4)**.
2. Fatal and serious severity ratio: If the number of fatal and serious accidents at the site is greater than the limiting number specified in appendix A6.1, leave line **(5)** blank and go to line **(6)**. Otherwise, in line **(5)** enter the ratio of fatal/(fatal + serious) and serious/(fatal + serious) from the table A6.19 series (all movements, all vehicles).
3. Multiply the total fatal + serious accidents **(4)** by the ratios **(5)** to get the adjusted fatal and serious accidents **(6)** for the reporting period. For minor and non-injury accidents, transfer the accident numbers from **(4)**. To get the accidents per year **(7)**, divide **(6)** by **(3)**.
4. Enter the adjustment factor for the accident trend from table A6.1(a) in line **(8)**. Multiply **(7)** by **(8)** to obtain the accidents per year (at time zero) for each accident category **(9)**.
5. Enter the under-reporting factors from tables A6.20(a) and A6.20(b) in line **(10)**. Multiply **(9)** by **(10)** to get the total estimated accidents per year **(11)**.
6. Enter the accident costs for 100km/h speed limit **(12)** and 50 km/h speed limit **(13)** for each accident category (all movements, all vehicles) from the table A6.21 series. Calculate the mean speed adjustment for the do minimum [(**(1)** - 50) divided by 50] in **(14)**.
7. Calculate the cost per accident for the do minimum **(15)** by adding **(**13**)** plus **(14)** and then multiplying this by the difference between accident costs in **(12)** and **(13)**.
8. Multiply accidents per year **(11)** by **(15)** to get cost per accident per year **(16)**. Add the costs for fatal, serious, minor and non-injury accidents in line **(16)** to get the total accident cost per year **(17)**.

Worksheets A6: Accident cost savings, continued

Accident by accident analysis - do minimum - EXAMPLE **Worksheet A6.2**

	Project option	Oblong realignment		
	Movement category	Head on	Vehicle involvement	All vehicles
1	Do minimum mean speed	65 km/h	Road category	Rural strategic
	Posted speed limit	100 km/h	Traffic growth rate	2%

	Do minimum		**Severity**			**Non-injury**
			Fatal	**Serious**	**Minor**	
3	Number of years of typical accident rate records		5			
4	Number of reported accidents over period		1	1	5	7
5	Fatal/serious severity ratio (tables A6.19(a) to (c))		0.33	0.67		
6	Number of reported accidents adjusted by severity **(4)** × **(5)**		0.66	1.33	5	7
7	Accidents per year = **(6)**/**(3)**		0.136	0.264	1	1.4
8	Adjustment factor for accident trend (table A6.1(a))		1.02			
9	Adjusted accidents per year = **(7)** x **(8)**		0.139	0.269	1.02	1.43
10	Under-reporting factors (tables A6.20(a) and (b))		1.0	2.0	4.0	20
11	Total estimated accidents per year = **(9)** x **(10)**		0.139	0.538	4.08	28.60
12	Accident cost, 100 km/h limit (tables A6.21(e) to (h))		3,900,000	440,000	30,000	4,000
13	Accident cost, 50 km/h limit (tables A6.21(a) to (d))		3,100,000	370,000	23,000	2,400
14	Mean speed adjustment = (**(1)** - 50)/50		0.3			
15	Cost per accident = **(13)** + **(14)** x [**(12)** – **(13)**]		3,340,000	391,000	25,100	2,880
16	Accident cost per year = **(11)** x **(15)**		464,260	210,358	102,408	82,368
17	Total cost of accidents per year (sum of columns in row **(16)** fatal + serious + minor + non-injury)	$	859,394			

Worksheets A6: Accident cost savings, continued

Explanation for worksheet A6.3 **Accident by accident analysis - options**

There must be 5 years or more accident data for the site and the number and types of accidents must meet the specifications set out in appendix A6.1 and A6.2.

1. Determine the forecast percentage accident reduction for each accident category **(18)**. Determine the proportion of accidents remaining [100% minus the percentage reduction in **(18)**] and record in **(19)**.
2. Calculate the predicted accidents per year **(20)** by multiplying the accidents per year of the do minimum **(11)** by the percentage of accidents remaining **(19)**.
3. Repeat the calculations from lines **(12)** through **(15)**, in lines **(21)** through **(24)** using the option mean speed **(2)**, to obtain the cost per accident for the option **(24)**.
4. Multiply the predicted number of accidents per year **(20)** by the cost per accident **(24)** to get the total accident costs per year for each accident category in line **(25)**. Add together the costs for fatal, serious, minor and non-injury accidents to get total accident costs per year **(26)**.

Worksheets A6: Accident cost savings, continued

Accident by accident analysis - option **Worksheet A6.3**

	Project option	Oblong realignment		
	Movement category	Head on	Vehicle involvement	All vehicles
2	Option mean speed	70 km/h	Road category	Rural strategic
	Posted speed limit	100 km/h		

	Option	Severity			Non-injury
		Fatal	**Serious**	**Minor**	
18	Percentage accident reduction	30	30	30	30
19	Percentage of accidents 'remaining' [100 – **(18)**]	70	70	70	70
20	Predicted accidents per year **(11)** x **(19)**	0.097	0.377	2.856	20.0
21	Accident cost, 100 km/h limit (tables A6.21(e) to (h))	3,900,000	440,000	30,000	4,000
22	Accident cost, 50 km/h limit (tables A6.21(a) to (d))	3,100,000	370,000	23,000	2,400
23	Mean speed adjustment = (**(2)** - 50)/50	0.4			
24	Cost per accident = **(22)** + **(23)** x [**(21)** – **(22)**]	3,420,000	398,000	25,800	3,040
25	Accident cost per year = **(20)** x **(24)**	331,740	150,046	73,685	60,860
26	Total cost of accidents per year (sum of columns in row **(25)** fatal + serious + minor + non-injury) $	616,331			

Worksheets A6: Accident cost savings, continued

Explanation sheet for accident rate analysis **Worksheet A6.4**

Worksheet A6.4 is used for accident rate analysis of the do minimum and/or project option(s) (or part of an option). This worksheet is used with accident costs from table A6.22 in appendix A6.9. Use several worksheets as necessary.

Header Fill in the boxes for project option, posted speed limit and road category.

1 or 1a Determine whether an accident prediction model or exposure-based accident prediction equation will be used to establish the typical accident rate (see appendix A6.5), and enter the reference number in **(1)** or **(1a)**.

Then, either

2 Enter parameter b_0 from table identified in **(1)**.

3 Enter parameter b_1 from table identified in **(1)**.

4 Enter parameter b_2 from table identified in **(1)**, if applicable.

5 Enter traffic volume of the minor approach.

6 Enter traffic volume of the major approach.

7 Calculate the typical accident rate by using the appropriate formula from appendix A6.5.

Or

2a Enter the b_0 coefficient from the table/section identified in **(1a)**.

3a Enter the cross-section adjustment factor from table A6.13, if appropriate (if not, use 1.0 for **(3a)**). Adjustment is only applied when the seal width differs from the base seal width given for each flow band (6.7, 8.2 and 9.5 m).

4a Adjust the b_0 coefficient using the cross-section adjustment factor, by multiplying **(2a)** by **(3a)**.

5a Determine the exposure X for the traffic volume at time zero.

7 Calculate the typical accident rate by multiplying **(4a)** by **(5a)**.

8 Determine the factor for adjusting the typical accident rate based on the posted speed limit from appendix A6.4 method B.

9 Calculate the adjustment factor for accident trend from **(8)** and the time in years from the time zero year to year 2006, refer to appendix A6.4 method B.

10 Adjust the typical accident rate for accident trends by multiplying **(7)** by **(9)**.

11 Enter the cost per accident from table A6.22 in appendix A6.9. Use the appropriate accident costs for the posted speed limit.

12 Calculate the total accident cost per year by multiplying the typical accident rate **(10)** by the cost per reported injury accident **(11)**.

Worksheets A6: Accident cost savings, continued

Accident rate analysis **Worksheet A6.4**

	Project option		
	Posted speed limit	Traffic growth rate	
	Road category	Time zero	

	Accident prediction model	
1	Table used	
2	Parameter b_0	
3	Parameter b_1	
4	Parameter b_2	
5	Lowest or sideroad AADT, Q_{minor}	
6	Highest or primary AADT, Q_{major}	
7	Typical accident rate (accidents per year), A_T (appendix A6.5).	

Go to step 8

	Exposure-based accident prediction equation	
1a	Table used	
2a	Coefficient b_0 (/10^8 veh-km or /10^8 vehicles)	
3a	Cross-section adjustment factor from table A6.13 (1.0 for no adjustment)	
4a	Adjusted coefficient **(2a)** x **(3a)**	
5a	Exposure at time zero (10^8 veh-km or 10^8 vehicles)	
7	Typical accident rate (accidents per year), A_T **(4a)** x **(5a)**	

8	Accident trends factor for adjusting typical accident rate (appendix A6.4 method B)	
9	Adjustment factor for accident trend (1 + **(8)** x (time zero year - 2006) (appendix A6.4 method B)	
10	Typical accident rate per year adjusted for accident trends, A_T **(7)** x **(9)**	
11	Cost per reported injury accident (table A6.22)	
12	Total accident cost per year **(10)** x **(11)**	

Worksheets A6: Accident cost savings, continued

Explanation sheet for weighted accident procedure – do minimum **Worksheet A6.5**

Worksheet A6.5 is used for the weighted accident procedure analysis of the do minimum. This worksheet uses the accident costs from table A6.22 in appendix A6.9.

Header Fill in the boxes for project option, posted speed limit and road category.

1 Enter the number of years of accident records used in the analysis (refer to appendix A6.2).

2 Enter the number of reported injury accidents that occurred during the accident period.

3 Calculate the number of accidents per year by dividing **(2)** by **(1)**.

4 Enter the adjustment factor for general accident trends for the appropriate speed limit category and traffic growth rate from table A6.1(a), appendix A6.4.

5 Calculate the site-specific accident rate (A_S) by multiplying the number of accidents per year **(3)** by the trend adjustment factor **(4)**.

6 or 6a Determine whether an accident prediction model or exposure-based accident prediction equation will be used to establish the typical accident rate (see appendix A6.5), and enter the reference number in **(6)** or **(6a)**.

Then, either

7 Enter parameter b_0 from table identified in **(6)**.

8 Enter parameter b_1 from table identified in **(6)**.

9 Enter parameter b_2 from table identified in **(6)**, if applicable.

10 Enter traffic volume of the minor approach.

11 Enter traffic volume of the major approach.

12 Calculate the typical accident rate by using the appropriate formula from appendix A6.5.

Or

7a Enter the b_0 coefficient from the reference identified in **(6a)**.

8a Enter the cross-section adjustment factor from table A6.13, when the seal width differs from the base seal width given for each flow band (6.7, 8.2 and 9.5 m). If not, use 1.0 for **(8a)**.

9a Adjust coefficient b_0 using the cross-section adjustment factor, by multiplying **(7a)** by **(8a)**.

10a Determine the exposure X for the traffic volume at time zero.

12 Calculate the typical accident rate by multiplying **(9a)** by **(10a)**.

13 Determine the accident trend factor for adjusting the typical accident rate based on the posted speed limit from appendix A6.4 method B.

14 Calculate the adjustment factor for accident trend from **(13)** and the time in years from the time zero year to year 2006 refer to appendix A6.4 method B.

15 Adjust the typical accident rate for accident trends by multiplying **(12)** by **(13)**. For mid-blocks, the typical accident rate should be divided by the length because the k value is calculated for a 1 kilometre mid-block section.

16 Obtain the k value for the accident prediction model or exposure-based accident prediction equation from appendix A6.5.

17 Assess the accident history reliability (refer to appendix A6.3), or use default value of 1.0.

18 Assess the reliability of the accident prediction equation (refer to appendix A6.3 and A6.5), or use default value of 1.0.

19 Calculate the value of the weighting factor using the formula provided (refer to appendix A6.3).

20 Calculate the weighted accident rate ($A_{W,dm}$) using the formula provided. The formula uses the site-specific accident rate **(5)**, the typical accident rate **(15)** and the weighting factor **(19)**.

21 Enter the cost per accident from table A6.22 in appendix A6.9. Use the appropriate accident costs for the posted speed limit.

22 Calculate the total accident cost per year by multiplying the do minimum weighted accident rate **(20)** by the cost per reported injury accident **(21)**.

Worksheets A6: Accident cost savings, continued

Weighted accident procedure – do minimum **Worksheet A6.5**

	Project option		
	Posted speed limit	Traffic growth rate	
	Road category	Time zero	

	Site specific accident rate	
1	Number of years of accident records	
2	Number of reported injury accidents over period	
3	Number of accidents per year **(2)**/**(1)**	
4	Trend adjustment factor (table A6.1(a))	
5	Site-specific accident rate (accidents per year), A_S **(3)** x **(4)**	
	Accident prediction model	
6	Table used	
7	Parameter b_0	
8	Parameter b_1	
9	Parameter b_2	
10	Lowest or sideroad AADT, Q_{minor}	
11	Highest or primary AADT, Q_{major}	
12	Typical accident rate (accidents per year), $A_{T,dm}$ (formula from appendix A6.5)	

Go to step 13

	Exposure based accident prediction equation	
6a	Table used	
7a	Coefficient b_0 (/10^8 veh-km or /10^8 vehicles)	
8a	Cross-section adjustment factor from table A6.13 (1.0 for no adjustment)	
9a	Adjusted coefficient **(7a)** x **(8a)**	
10a	Exposure at time zero (10^8 veh-km or 10^8 vehicles)	
12	Typical accident rate (accidents per year), $A_{T,dm}$ **(9a)** x **(10a)**	
13	Accident trend factor for adjusting typical accident rate, f_t (appendix A6.4 method B).	
14	Adjustment factor for accident trend (1 + **(8)** x (time zero year - 2006) (appendix A6.4 method B).	
15	Typical accident rate per year adjusted for accident trends, $A_{T,dm}$ **(12)** x **(14)***	
	Weighting factor	
16	k value (appendix A6.5)	
17	Reliability of accident history, α_X (default is 1.0)	
18	Reliability of accident prediction model or equation, α_M (default is 1.0)	
19	Weighting factor, w, $(17)^2$ x **(16)** / ($(17)^2$ x **(16)** + $(18)^2$ x **(15)**))	

20	Do minimum weighted accident rate, $A_{W,dm}$ [**(19)** x **(15)**] + [1 – **(19)**] x **(5)**	
21	Cost per reported injury accident (table A6.22)	
22	Total do minimum accident cost per year **(20)** x **(21)**	

- * For all mid-block analyses, the typical accident rate **(15)** must be divided by the mid-block length (in km).

Worksheets A6: Accident cost savings, continued

Explanation sheet for weighted accident procedure – option **Worksheet A6.6**

Worksheet A6.6 is used for weighted accident procedure analysis of the project options. This worksheet uses the accident costs from table A6.22 in appendix A6. Use one worksheet for each option.

Header Fill in the boxes for project option, posted speed limit and road category.

1 or 1a Determine whether an accident prediction model or exposure-based accident prediction equation will be used to establish the typical accident rate (see appendix A6.5), and enter the reference in **(1)** or **(1a)**.

Then, either

2 Enter parameter b_0 from table identified in **(1)**.

3 Enter parameter b_1 from table identified in **(1)**.

4 Enter parameter b_2 from table identified in **(1)**, if applicable.

5 Enter traffic volume of the minor approach.

6 Enter traffic volume of the major approach.

7 Calculate the typical accident rate by using the appropriate formula from appendix A6.

Or

2a Enter the b_0 coefficient from the reference identified in **(1a)**.

3a Enter the cross-section adjustment factor from table A6.13, when the seal width differs from the base seal width given for each flow band (6.7, 8.2 and 9.5 m). If not, use 1.0 for **(3a)**.

4a Adjust the b_0 coefficient using the cross-section adjustment factor, by multiplying **(2a)** by **(3a)**.

5a Determine the exposure X for the traffic volume at time zero.

7 Calculate the typical accident rate by multiplying **(4a)** by **(5a)**.

8 Determine the factor for adjusting the typical accident rate based on the posted speed limit from appendix A6.4 method B.

9 Calculate the adjustment factor for accident trend from **(8)** and the time in years from the time zero year to year 2006, refer to appendix A6.4 method B.

10 Adjust the typical accident rate for accident trends by multiplying **(7)** by **(9)**.

11 Obtain the do minimum typical accident rate ($A_{T,dm}$) from worksheet A6.5 row **(15)**.

12 Obtain the weighted accident rate for the do minimum ($A_{W,dm}$) from worksheet A6.5 row **(20)**.

13 Calculate the weighted accident rate for the option ($A_{W,opt}$) using the formula provided.

14 Enter the cost per accident from table A6.22 in appendix A6. Use the appropriate accident costs for the posted speed limit.

15 Calculate the total accident cost per year by multiplying the option weighted accident rate **(13)** by the cost per reported injury accident **(14)**.

Worksheets A6: Accident cost savings, continued

Weighted accident procedure – option **Worksheet A6.6**

	Project option		
	Posted speed limit	Traffic growth rate	
	Road category	Time zero	

	Accident prediction model	
1	Table used	
2	Parameter b_0	
3	Parameter b_1	
4	Parameter b_2	
5	Lowest or sideroad AADT, Q_{minor}	
6	Highest or primary AADT, Q_{major}	
7	Typical accident rate (per year), $A_{T,opt}$ (formula from appendix A6.5)	

Go to step 8

	Exposure-based accident prediction equation	
1a	Table used	
2a	Coefficient b_0 (/10^8 veh-kms or /10^8 vehicles)	
3a	Cross-section adjustment factor from table A6.13 (1.0 for no adjustment)	
4a	Adjusted coefficient **(2a)** x **(3a)**	
5a	Exposure at time zero (10^8 veh-kms or 10^8 vehicles)	
7	Typical accident rate (accidents per year), $A_{T,opt}$ **(4a)** x **(5a)**	
8	Accident trends factor for adjusting typical accident rate (appendix A6.4 method B)	
9	Adjustment factor for accident trend (1 + **(8)** x (year zero - 2006) (appendix A6.4 method B)	
10	Typical accident rate per year adjusted for accident trends, A_T **(7)** x **(9)**	
	Weighted accident rate	
11	Do minimum typical accident rate, $A_{T,dm}$ (from worksheet A6.5)	
12	Do minimum weighted accident rate, $A_{W,dm}$ (from worksheet A6.5)	
13	Option weighted accident rate, $A_{W,opt}$ **(10)** x **(12)** / **(11)**	
14	Cost per reported injury accident (table A6.22)	
15	Total option accident cost per year **(13)** x **(14)**	

Worksheets A6: Accident cost savings, continued

Explanation sheet for worksheet A6.7 **Accident rate analysis - urban routes**

Worksheet A6.7 may be used for accident rate analysis in place of worksheet A6.4 for urban routes consisting of a number of road types. Parameters for the accident rate prediction models in appendix A6.5 have been provided in this worksheet.

1	Mid-block road type	Break the urban route being analysed into the various mid-block types, in accordance with the official road hierarchy in the urban area. An urban route has a commercial land use when over 50 percent of the adjoining land use is either commercial or industrial, otherwise it is an 'other' land use. Where possible separate out mid-block sections in commercial and industrial areas.
2	AADT range	Check that the traffic flow in each mid-block section falls within the AADT range specified. Where traffic flows are outside these ranges then this should be specified in the evaluation report, as this will affect the accuracy of the evaluation. The AADT is the daily one way traffic volume on the road section.
3	Length in km, L	Enter the length of mid-block section of each road type. If there is a significant difference in traffic flows on various mid-block sections of each road type then add extra rows to bottom of table.
4	Current AADT, Q_c	Enter average annual daily traffic for do minimum at time zero. Where AADTs vary between mid-block sections, use the average.
5	AADT after implementation, Q_d	Enter average annual daily traffic volume for each option at time zero. Where AADTs vary between mid-block sections, use the average.
6	Parameter b_0	Typical accident rate prediction model parameter from appendix A6.5
7	Parameter b_1	Typical accident rate prediction model parameter from appendix A6.5
8	Do minimum link accident rate, A_c	For each mid-block road type calculate the do minimum accident rate using current AADT **(4)** and the equation provided from appendix A6.5.
9	Option link accident rate, A_d	For each mid-block road type calculate the option accident rate using the AADT after implementation **(5)** and the equation provided from appendix A6.5.
10	Change in link accident rate, A_L	For each mid-block road type calculate the difference between the do minimum **(8)** and option **(9)** accident rates.
11	Intersection adjustment	For collectors and arterials add in the accident rate for intersections by multiplying mid-block accident rates by 2.0. This assumes that approximately 50 percent of accidents occur at intersections. If there is information that is contrary to this assumption then it is permissible, with supporting evidence, to use a factor other than 2.0.
12	Cost per reported injury accident, A_z	Obtain cost per reported injury accident from table A6.22 'all other sites' in appendix A6.5. Where there is more than one speed limit for each road type, then use the cost associated with most prevalent speed limit. Alternatively, break road types into each speed limit zone.
13	Accident cost per link type, C	Calculate the accident cost per link type using the change in accident rate, adjusted for intersections **(11)** and the cost per reported injury accident **(12)**.
14	Accident cost saving for urban section per year	Sum the accident cost per link type **(13)** to obtain the accident cost saving for the urban section of the proposal per year.

Worksheets A6: Accident cost savings, continued

Accident rate analysis - urban routes **Worksheet A6.7**

Project option _____

Posted speed limit _____

Road category _____

Mid-block road type	AADT range	Length in km	Current AADT	AADT after	Parameter		Do minimum accident rate	Option accident rate	Change in link accident rate	Intersection adjustment factor	Cost per reported injury accident	Accident cost per link type
		L	Q_c	Q_d	b_0	b_1	$A_c = b_0 \times Q_c^{b1} \times L$	$A_d = b_0 \times Q_d^{b1} \times L$	$A_L = A_c - A_d$	$A_T = A_L \times 2$	Az (table A6.22)	$C = A_T \times A_z$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Local street –commercial land use	< 3,000				2.53×10^{-4}	0.98				$A_T = A_L$		
Collector – commercial land use	2,000 to 8,000				2.24×10^{-5}	1.08						
Collector – other land use	2,000 to 8,000				3.46×10^{-5}	1.08						
2 and 4 lane arterial – commercial land use	3,000 to 24,000				7.66×10^{-6}	1.20						
2 and 4 lane arterial – other land use	3,000 to 24,000				1.34×10^{-4}	0.88						
Motorway (each direction)	15,000 to 68,000				2.96×10^{-7}	1.45				$A_T = A_L$		
4-lane divided rural road (each direction)	15,000 to 68,000				3.55×10^{-7}	1.45				$A_T = A_L$		

14 Accident cost saving for urban section per year (sum of column **(13)**) _____

Worksheets A6: Accident cost savings, continued

Explanation sheet for worksheet A6.8 **Accident rate analysis - rural two lane HCV**

Worksheet A6.8 may be used for accident rate analysis in place of worksheet A6.4 for rural routes consisting of a number of different terrain and AADT volume types. Refer to appendix A6.5 (12).

1	Road section	Break the rural route up into a number of sections, according to terrain type **(2)** and average annual daily traffic volume **(3)**.
2	AADT	Specify the AADT for each rural road section. A distinction should be made between road sections with AADT < 4,000 and those with AADT ≥ 4,000, as different accident rates apply.
3	Terrain type	Specify the terrain type for each rural road section. A road section is specified as **flat** when the gradient typically varies from zero to three percent; **rolling** when the gradient is typically in the range three to six percent; above six percent the terrain type is **mountainous**. In mountainous sections, low gradients, between three and six percent, are acceptable, as long as they are short and occur within a predominantly mountainous section of road.
4	Current number of HCVs per day, T_c	For each road section specify the current number of HCVs per day from classified traffic counts.
5	Number of HCVs after implementation, T_d	For each road section calculate the number of HCVs that will be removed from the rural route (generally this will be the same over the entire route). Subtract this from the current number of HCVs per day **(4)** to get the number of HCVs after implementation of the proposal.
6	Length in km, L	Calculate the length of each road section.
7	Do minimum HCV exposure, X_c	The do minimum HCV exposure is the current number of HCV kilometres of travel per year for each road section, expressed in 100 million HCV kilometres of travel. Use the formula provided.
8	Option HCV exposure, X_d	The option HCV exposure is the number of HCV kilometres of travel per year on each road section following implementation of the proposal, expressed in 100 million HCV kilometres of travel. Use the formula provided.
9	Accident rate parameter, b_0	The accident rate parameter b_0, for each road section is selected from appendix A6.5 (12) HCV rural two lane roads ≥ 80 km/h, based on terrain type and AADT.
10	Do minimum accidents per year, A_c	The do minimum accident rate per year is the accident rate parameter **(9)**, multiplied by the do minimum HCV exposure **(7)**.
11	Option accidents per year, A_d	The option accident rate per year is calculated by multiplying the accident rate parameter **(9)**, by the option HCV exposure **(8)**.
12	Change in link accident rate, A_L	The change in the link accident rate is the difference between the do minimum **(10)** and option **(11)** accident rate per year.
13	Cost per reported accident, A_z	Obtain cost per reported accident from table A6.22 'all other sites' in appendix A6.9. Where there is more than one speed limit in each road section, use cost associated with the most prevalent speed limit. Alternatively, analyse as sections by speed limit.
14	Accident cost per section, C	Calculate accident cost per road section using the change in accident rate **(12)** and cost per reported injury accident **(13)**.
15	Accident cost saving for rural section of proposal per year	Sum the accident cost per road section type **(14)** to obtain accident cost savings for the rural section of the proposal per year.

Worksheets A6: Accident cost savings, continued

Accident rate analysis – rural two lane HCV **Worksheet A6.8**

Project option _____

Posted speed limit _____

Road category _____

Road section	AADT	Terrain	Length in km	Current HCV AADT	HCV AADT after	Do minimum HCV exposure	Option HCV exposure	Parameter	Do minimum accident rate	Option accident rate	Change in link accident rate	Cost per reported injury accident	Accident cost per link type
		(table A6.14)	L	T_c	T_d	$X_c = T_c \times L \times 365/10^8$	$X_d = T_d \times L \times 365/10^8$	b_0 (Table A6.14)	$A_c = b_0 \times X_c$	$A_d = b_0 \times X_d$	$A_L = A_c - A_d$	Az (table A6.22)	$C = A_L \times A_z$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)

15 Accident cost saving for urban section per year (sum of column **(14)**) _____

Worksheets A7: Vehicle passing options

Explanation sheet for passing lane strategy analysis **Worksheet A7.1**

This worksheet is used in the analysis of passing lane strategies. The worksheet is completed as follows.

1	Project option	Enter the project option.
2	Initial analysis year	Enter the initial analysis year for the strategy.
3	Road section	Enter the name and simple description of the road section under consideration, see appendix A7.3.
4	Sub-section	For each-subsection (see appendix A7.3) enter: • Sub-section name. • Start description (route position if applicable). • Finish description (route position if applicable). • Sub-section length. • Traffic growth rate (as percentage of analysis year).
5	AADT	Enter the AADT for the analysis year and each five year increments up to 20 years.

Worksheets A7: Vehicle passing options, continued

Passing lane strategy analysis – EXAMPLE **Worksheet A7.1**

1	Project option	passing lane strategy example
2	Initial analysis year	2006
3	Road section	from 109/0 to 200/7 (increasing direction)

4

Sub-section number	Sub-section name	Start	Finish	Length	Growth rate	AADT				
						Analysis year	+5 years	+10 years	+15 years	+20 years
1	Sub-section 1	109/0	130/0	21	2%	3250	3575	3900	4225	4500
2	Sub-section 2	130/0	144/12	24	2%	3363	3700	4035	4372	4709
3	Sub-section 3	160/2	160/13	11	2%	3133	3446	3760	4073	4386
4	Sub-section 4	180/5	200/7	20	2%	4036	4439	4843	5247	5650

Worksheets A7: Vehicle passing options, continued

Explanation sheet for passing lane strategy analysis summary **Worksheet A7.2**

This worksheet is used in the analysis of passing lane strategies. The worksheet is completed as follows.

1	Project option	Enter the project option.
2	Initial analysis year	Enter the initial analysis year for the strategy.
3	Road section	Enter the name and simple description of the road section under consideration (see appendix A7.3).
	For each sub-section enter:	
4	Generalised gradient	The sum of the absolute rises and falls, expressed in metres/km.
5	Generalised curvature	The sum of the horizontal deviation expressed as degrees of curvature per km.
6	Terrain type	Using **(4)** and **(5)** to determine the terrain type from table A7.5.
7	Percent PSD	Enter the percent of road with safe passing sight distance.
8	Method	Identify the method used to determine the proportion of road with passing sight distance.
9	BCR and spacing	For the given terrain type **(6)**, percent of road with safe passing sight distance **(7)**, and the AADT (worksheet A7.1) determine from figures A7.3 to A7.6 the benefit cost ratio assuming a 2% traffic growth. Use the appropriate factor from table A7.7 to adjust the benefit cost ratio for traffic growth. Repeat this procedure to determine the optimal passing lane strategy in five year increments. The optimal strategy for any particular analysis year is determined by considering in turn the BCR for each spacing alternative, beginning with the closest passing lane spacing strategy. If, when all other aspects of the strategy are taken into account, the BCR for the closest spacing is not sufficient to obtain funding (refer Land Transport NZ's National Land Transport Programme) consider the next most frequent passing lane strategy.

Worksheets A7: Vehicle passing options, continued

Passing lane strategy analysis summary – EXAMPLE **Worksheet A7.2**

1	Project option	passing lane strategy example
2	Initial analysis year	2006
3	Road section	from 109/0 to 200/7 (increasing direction)

Sub-section number	Generalised gradient	Generalised curvature	Terrain type	PSD %	Method	Passing lane spacing strategy and BCR (9)									
						Analysis year		+5 years		+10 years		+15 years		+20 years	
	(4)	(5)	(6)	(7)	(8)	BCR	Spacing	BCR	Spacing	BCR	Spacing	BCR	Spacing	BCR	Spacing
1	45-60	150-300	Hilly	10%	A7.5	1.8	5	2.0	5	2.8	5	3.0	5	3.2	5
2	20-45	50-150	Rolling	15%	A7.5	2.0	5	2.8	5	3.5	5	4.2	5	4.8	5
3	>60	150-300	Mountainous	10%	A7.5	1.0	5	1.3	5	1.5	5	1.8	5	2.1	5
4	20-45	50-150	Rolling	15%	A7.5	3.0	5	3.8	5	4.8	5	5.6	5	6.2	5

Worksheets A7: Vehicle passing options, continued

Explanation sheet for individual passing lane analysis **Worksheet A7.3**

This worksheet is used for the analysis of individual passing lanes within an overall strategy. The worksheet is completed as follows:

1 Costs — Enter costs for the do minimum and option.

2 Data
- Enter the passing lane spacing from the passing lane strategy. If an isolated passing lane enter 20 km.
- Enter the terrain type (from worksheet A7.2 or table A7.5).
- Enter the AADT for the analysis year.
- Enter traffic growth (expressed as a proportion of the time zero AADT).
- Enter the percentage of road with safe passing sight distance.
- Enter the length of the passing lane excluding tapers.
- Enter the proportion of heavy vehicles (the sum of the proportions of MCV, HCVI and HCVII).
- Enter the coefficient of variation of vehicle speeds if available. If not enter the default value of 13.5%.

3 Calculations
- Determine the travel time and vehicle operating cost savings from figure A7.7 and multiply with the appropriate factors from table A7.9 and table A12.2.
- Determine the driver frustration benefits from figure A7.8 and multiply with the appropriate factors from table A7.9 and table A12.2.
- Calculate the base value of road user benefits.
- Enter the passing lane length adjustment from table A7.11.
- Adjust the base road user benefits.
- Adjust for variations in the proportion of heavy vehicles at the site.
- Adjust for variations in the distribution of vehicle speeds at the site.
- Determine the accident cost savings from figures A7.9 to A7.12. Multiply by the appropriate factor from table A7.12 and table A12.2. Alternatively, if appropriate, use accident by accident analysis.
- Calculate the total benefits.
- Calculate the total costs.

4 BCR — Calculate the benefit cost ratio.

Worksheets A7: Vehicle passing options, continued

Individual passing lane analysis - EXAMPLE **Worksheet A7.3**

	Project option				
1	**Costs**				
	Do minimum		$	0	**A**
	Project option		$	350,000	**B**
2	**Data**				
	Passing lane spacing	(5, 10 or 20 km)		5	km
	Terrain type	(See table A7.5)		Rolling	
	Analysis year AADT	(vehicles/day)		4036	
	Traffic growth	(per year)		2	%
	% PSD	(proportion)		0.15	
	Passing lane length			1.1	km
	Heavy vehicles	(proportion)		0.14	**C**
	COV of speed	(proportion)		0.125	**D**
3	**Calculations**				
	Travel time, VOC savings	figure A7.7, adjusted using table A7.9 and table A12.2	$	860,000	**E**
	Driver frustration benefits	figure A7.8, adjusted using table A7.10 and table A12.2	$	81,000	**F**
	Base road user benefits	(**E** + **F**)	$	941,000	**G**
	Passing lane length factor	Table A7.11		1.07	**H**
	Passing lane length adjustment	(**G** × **H**)	$	1,006,870	**I**
	Heavy traffic adjustment	**I** x [1 + (**C** – 0.12)]	$	1,027,007	**J**
	Adjust for COV of speed	**J** x [1 + (**D** – 0.135) × 2.5]	$	1,001,332	**K**
	Accident cost savings	figures A7.9 to A7.12 adjusted using table A7.12 and table A12.2, or by accident by accident analysis	$	430,000	**L**
	Benefits	(**K** + **L**)	$	1,431,332	**Y**
	Costs	(**B** – **A**)	$	350,000	**Z**
4	**Benefit cost ratio**	(**Y**/**Z**)		4.1	

Worksheets A8: External impacts

Explanation sheet for external impacts summary **Worksheet A8.1**

Worksheet A8.1 is used to record external impacts. Refer to appendix A8 for guidance on the description, quantification and indicative valuation of external impacts.

1	Project option	Enter the project option.
2	Nature of impacts	Enter the types of monetised impacts
3	Description of impacts	Describe: • The groups affected. These may be residents of nearby properties, users of recreational facilities, pedestrians and cyclists, vehicle occupants, etc. They may also include flora and fauna affected by the proposed project. • The extent of the effect, incl. The size of the impacts, eg, increases in noise decibels, the number of households affected. If applicable, also state the time and duration of the effect.
4	Basis for valuing impacts	Where it is feasible to derive a value for the external impact, describe the basis for valuing the effect.
5	Value of impacts	Calculate the value of the effect in dollars per unit per year by multiplying the numbers affected **(3)** by the unit value of the effect **(4),** or otherwise determine an overall value of the effect.
6	Annual value of monetised impacts	Calculate for all monetised impacts by add the values of the individual impacts in **(5)** to determine the annual dollar value.
7	Present value of monetised impacts	Calculate the present value of all monetised impacts by multiplying the annual value in **(6)** by 10. This figure approximates the USPWF for a 25 year evaluation period and makes some allowance for increases in the value of monetised benefits and costs in real terms over time.

Worksheets A8: External impacts, continued

External impacts summary - EXAMPLE **Worksheet A8.1**

1 Project option Alignment D

Nature of impact (2)	Description of impacts (3)	Basis for valuing impacts (4)	Value of impacts (5)
Noise	Reduced noise of 4 dB(A) to pedestrians and adjacent houses (300 houses)	Reduced noise to individuals and residential buildings $190 per dB(A) x 300 houses	$228,000
Air pollution	Reduction in PM10 of 0.05 mg/m^3 for 3 months of the year for city of 100,000	$40 per year per person exposed per mg increase	$50,000
Visual impact	Restricted view of the museum due to the new infrastructure, affecting visitors and local residents (50,000 people/yr).	Estimated value per person of reduced view of the building	($50,000)
Severance	No change		
Special areas	Improved access to the recreation area and reduced disturbance from the arterial road to the recreation area.	Increased number of people using the facility, and greater enjoyment for the users.	$100,000
Access	No change		

6	Annual value of monetised impacts(un-discounted)	$328,000
7	Present value of monetised impacts (annual value x 10)	$3,280,000

Worksheets A8: External impacts, continued

Explanation sheet for analysis of environmental mitigation measures **Worksheet A8.2**

This worksheet is used to analyse environmental mitigation measures incorporated in the preferred project option.

1	Project option	Enter the preferred project option.
2	Description	Describe the environmental mitigation measure.
3	Effect being mitigated	Describe the effect being mitigated.
4	Additional cost	Enter the additional cost of the environmental mitigation measure to the project.
5	Additional benefit	Enter the benefits of the environmental mitigation measure. The benefits of measures to reduce effects is assessed in accordance with the procedures specified in appendix A8.
6	BCR	Calculate the BCR of the mitigation measure by dividing column **(4)** by column **(3)**.

Worksheets A8: External impacts, continued

Analysis of environmental mitigation measures – EXAMPLE **Worksheet A8.2**

1 Project option Option A

Description of mitigating measure (2)	Effect being mitigated (3)	Cost of measure (4)	Benefit of measure (5)	BCR (6) = (5) / (4)
Elevated roadway to allow existing kauri tree roots to remain	Damage to kauri tree roots and hence the kauri trees	$0.5m	$2.0m	4.0

Worksheets A8: External impacts, continued

Explanation sheet for road traffic noise **Worksheet A8.3**

This worksheet is used for comparing predicted noise levels with the ambient noise levels and the design guidelines. If the project is small, it may be possible to accommodate all project options on one sheet.

1	Project option	Enter the name of the project option.
2	Facility affected	Describe the types of facility affected by noise related to the project, ie, residences, educational facilities, shops and offices.
3	Numbers of households/ frontage length	Enter the number of households affected by noise or the length of frontage for other types of properties.
4	Ambient noise level	Determine the ambient noise level in accordance with appendix A8.2.
5	Predicted noise level	Determine the predicted noise level 10 years after the completion of the project by referring to appendix A8.2.
6	Predicted change	Calculate the change in noise level by subtracting the predicted noise level from the ambient noise level.
7	Noise design level	Determine the noise design level in accordance with appendix A8.2, table A8.1.
8	Variance from design guideline	Calculate the variance from the design level by subtracting the noise design level from the predicted noise level, **(6)** – **(7)**.

Worksheets A8: External impacts, continued

Road traffic noise - EXAMPLE **Worksheet A8.3**

Project option	Facility affected	Numbers of households/ frontage length (m)	Ambient noise level, (db(a))	Predicted noise level, (db(a))	Predicted change, (db(a))	Noise design level, (from table A8.1, db(a))	Variance from design guideline, (db(a))
(1)	(2)	(3)	(4)	(5)	(6) = (5) – (4)	(7)	(8) = (5) – (7)
Option A	Residences	100	52	68	16	62	6
		200	68	65	-3	70	-
	Schools	2	52	68	16	62	6
	Shops	200	68	65	-3	-	-
Option B	Residences	200	68	71	3	70	1
	Shops	200	68	71	3	-	-

Worksheets A9: Vehicle emissions

Explanation sheet for component vehicle emissions **Worksheet A9.1**

This worksheet is used to calculate the vehicle emissions from a road section based on the travel time. Several worksheets may be required to calculate the component vehicle emissions for a project option with multiple road sections or multiple time periods.

1	Project option	Enter the project option (eg, do minimum, option A, etc) and road section information from worksheet A4.1.
2	Road section length	Enter the road section length in km.
3	Travel time	Enter the section travel time from worksheet A4.1.
4	Average road section speed	Calculate the average road section speed as 60 x **(2)**/**(3)**.
5	AADT	Enter the ADDT for the road section.
6	% light vehicles	Enter the proportion of light vehicles as the sum of the passenger car and LCV %.
7	% heavy vehicles	Enter the proportion of heavy vehicles as the sum of the MCV, HCVI, HCVII and bus %.
8 – 12	Emission rate coefficients	These are the default emission rate coefficients from appendix A9.3.
13	Rate	Calculate the emission rate for each vehicle type and emission component using the equation from appendix A9.3 **(10)** x **(4)**^{2} + **(11)** x **(4)** + **(12)**.
14	Weighted	Calculate the weighted emission rate by multiplying the vehicle type emission rate by the appropriate % light or % heavy proportions from **(6)** or **(7)**.
15	Emission component total	Add together the light and heavy weighted emission rate to obtain the total for each emission component.
16	Emission component rate	Calculate the total emission component rate for the road section and time period by multiplying the emission component total rate **(15)** by the road section length **(2)** and the number of vehicles **(5)**.

Worksheets A9: Vehicle emissions, continued

Component vehicle emissions **Worksheet A9.1**

1	Project option (do minimum or option)	
	Road section	
	Time period	
2	Road section length (km)	
3	Travel time (min/vehicle)	
4	Average road section speed (km/h)	
5	AADT	
6	% light (Passenger + LCV)	
7	% heavy (MCV + HCVI + HCVII + Bus)	

	Emission (8)	Vehicle (9)	A (10)	B (11)	C (12)	Rate (13)	Weighted (14)
	CO	Light	3.6×10^{-3}	-0.545	25.5		
	CO	Heavy	6.47×10^{-4}	-0.11	7.31		
15	CO	Emission component total			Add light and heavy **(14)**		
16	CO	Emission rate			**(15)** x **(2)** x **(5)**		
	NOx	Light	2.46×10^{-4}	-0.0287	1.67		
	NOx	Heavy	2.04×10^{-3}	-0.275	17.4		
15	NOx	Emission component total			Add light and heavy **(14)**		
16	NOx	Emission rate			**(15)** x **(2)** x **(5)**		
	PM10	Light	2.45×10^{-5}	-0.00342	0.153		
	PM10	Heavy	3.82×10^{-4}	-0.0455	2.65		
15	PM10	Emission component total			Add light and heavy **(14)**		
16	PM10	Emission rate			**(15)** x **(2)** x **(5)**		
	VOC	Light	5.53×10^{-4}	-0.081	3.55		
	VOC	Heavy	3.07×10^{-4}	-0.0584	3.30		
15	VOC	Emission component total			Add light and heavy **(14)**		
16	VOC	Emission rate			**(15)** x **(2)** x **(5)**		

Worksheets A9: Vehicle emissions, continued

Explanation sheet for vehicle emissions summary **Worksheet A9.2**

This worksheet is used to summarise and calculate any monetised impact for vehicle emissions for the do minimum or option. Worksheet A9.1 can be used to calculate the emission rate as an input.

1	Project option	Enter the project option (eg, do minimum, option A, etc).
2	Road section	Enter the road section information from worksheet A4.1.
3	Time period	Enter the time period under consideration.
4	Time periods per year	Calculate the time periods per year in the period specified in **(3)**. For instance if time periods are hours and period is 7 am – 9 am on workdays the time periods per year is 2 (hours per period) × 245 (workdays per year) = 490.
5	Vehicle emission	Enter the vehicle emission component under consideration: CO_2, CO, NOx, PM10, or volatile organic compounds (VOC).
6	Emission rate	Enter the emission rate for the time period. The emission of CO, NOx, PM10, or VOC can be estimated from worksheet A9.1. CO_2 emissions are calculated below as described in Appendix A9.7. For road links Light CO_2 (in tonnes) = road section vehicle operating cost x 0.0015 Heavy CO_2 (in tonnes) = road section vehicle operating cost x 0.0028 No CO_2 savings can be claimed from shape corrections and reduced roughness costs. From modelling of intersection improvements Light CO_2 (in tonnes) = fuel consumption (in litres) x 0.0022 Heavy CO_2 (in tonnes) = fuel consumption (in litres) x 0.0025
7	Emission load	Calculate the emission load. Calculate the total emission load per year for the section using the formula: **(7)** = **(4)** × **(6)**.
8	Monetised impact	Where a value has been provided in Appendix A9, monetise the emission. For CO_2 • One tonne CO_2 = \$40 or, • 7.5% of vehicle operating cost. For PM10 • \$40/person/year exposed per PM10 microgram/m^3, or • 0.001 × ΔPM10 concentration × population exposed × normal death rate × value of life.

Worksheets A9: Vehicle emissions, continued

Vehicle emissions summary **Worksheet A9.2**

Option (1)	Road section/ movement (2)	Time period (3)	Time periods per year (4)	Vehicle emission (5)	Emission rate (6)	Emission load (7)	Monetised impact (8)

Worksheet A10: National strategic factors

Explanation sheet for national strategic factors **Worksheet A10**

Worksheet A10 is used to record national strategic factors. Guidance is given in appendix A10 regarding valuation of these factors.

1	Project option	Enter the project option.
2	Nature of factor	Enter the nature of the national strategic factor.
3	Description of factor	Describe the factors. Guidance is given in appendix A10 regarding those factors so far identified.
4	Basis for valuing factor	Describe the basis for valuing the factor. Guidance is given in appendix A10.
5	Value of factors	Calculate the present value of the factor(s).
6	Total present value of factors	Calculate the total present value of the national strategic factors (if there is more than one).

Worksheet A10: National strategic factors, continued

National strategic factors – EXAMPLE **Worksheet A10**

1 Project option Highway realignment

Nature of factor (2)	Description of factor (3)	Basis for valuing factor (4)	Value of factors (5)
Security of access	Reduces the probability from 0.05 to 0.01 of a slip obstructing access on a road carrying 2,000 AADT with the average alternative route delay of 35 minutes, and reduces the average duration of slip obstruction from 5 hours to 1 hour.	Calculate the reduced travel time costs of using the alternative route from the reduced frequency and duration of obstructed access due to slips. Compare with the results of survey of drivers' willingness to pay to reduce the frequency and duration of obstructed access due to slips.	$278,000 NPV vs $430,000 NPV Security of access NSF = $152,000 NPV
Investment option value	Realignment has two options – the more expensive option would allow for future addition of a passing lane and connection to a planned road, whereas the cheaper option would not permit the additions. Current best forecasts of the rate of traffic growth and urbanisation indicate that the four laning and connection may never be economic. However, the traffic growth forecasts are very uncertain. If the cheaper option is chosen now, and the highest-growth scenario eventuates, it may be impossible to provide the additions in the future due to planning constraints and extremely high costs of retrofitting. It is therefore recommended that the higher cost realignment is undertaken now, so that the ability to add the passing lane and road connection is retained.	It will cost an additional $300,000 to construct the more expensive option, preserving the ability to expand in the future. This represents a 9% increase in cost. However, this additional expenditure reduces the BCR from 4.1 to 3.7. The added capital cost of $300,000 compares favourably with the potential retrofitting cost of $1,500,000. However the probability of requiring retrofitting may be low. Therefore, careful consideration must be given to the final choice of preferred project option, and the rational for the final choice must be clearly provided.	

6 Present value of national strategic factors $152,000

Worksheets A13: Risk analysis

Explanation sheet for risk analysis worksheets **Worksheet A13**

Explanations and examples for the risk analysis worksheets are contained in appendix A13.

Worksheet	Explanation and examples
A13.1	Appendix A13.5 and A13.6
A13.2(a)	Appendix A13.7
A13.2(b)	Appendix A13.8
A13.3	Appendix A13.9

Worksheets A13: Risk analysis, continued

Summary of benefit risks **Worksheet A13.1**

A tick (✓) should be placed alongside any risk which is judged to be either 'low' or 'high'. Where detailed information on risks is unavailable for the sub-categories, an overall assessment should be given in the shaded row for the risk category as a whole.

Low rating		Benefit risks	High rating
	1	**Base travel demand**	
	1.1	Age of data source	
	1.2	Data scope	
	1.3	Data quantity and statistical reliability	
	1.4	Data validation	
	1.5	Travel composition	
	1.6	Other	
	2	**Growth forecasts**	
	2.1	High city population growth	
	2.2	Development-related traffic as proportion of scheme traffic	
	2.3	Time series projection	
	2.4	Other	
	3	**Assignment**	
	3.1	Other future projects	
	3.2	Path derivation method	
	3.3	Routeing parameters	
	3.4	Supply relationships	
	3.5	Convergence	
	3.6	Other	
	4	**Accidents**	
	4.1	Proportion of benefits accounted for by accidents	
	4.2	observed accident sample size	
	4.3	Judgemental accident reduction risk	
	4.4	Other	

Worksheets A13: Risk analysis, continued

Summary of cost risks **Worksheet A13.1**

A tick (✓) should be placed alongside any risk which is judged to be either 'low' or 'high'. Where detailed information on risks is not available for the sub-categories, an overall assessment should be given in the shaded row for the risk category as a whole.

Low rating		Cost risks	High rating
	5	**Environmental and planning**	
	5.1	Tangata whenua issues	
	5.2	Emissions	
	5.3	Landscape and visual	
	5.4	Ecological effects	
	5.5	Archaeological and historic sites	
	5.6	Social networks and severance	
	5.7	Economic/amenity impacts on land users	
	5.8	Natural hazards	
	5.9	Other	
	6	**Land and Property**	
	6.1	Property acquisition	
	6.2	Property economic value	
	6.3	Other	
	7	**Earthworks**	
	7.1	Knowledge of ground conditions	
	7.2	Complex/unpredictable conditions	
	7.3	Road design form	
	7.4	Extent of topographical data	
	7.5	Source and disposal of material	
	7.6	Other	
	8	**Other Engineering Costs**	
	8.1	Engineering complexity	
	8.2	Other	
	9	**Services**	
	9.1	Existence, location and condition	
	9.2	Site flexibility	
	9.3	Cooperation of utilities	
	9.4	Other	

Worksheets A13: Risk analysis, continued

Summary of other risks **Worksheet A13.1**

A tick (✓) should be placed alongside any risk which is judged to be either 'low' or 'high'. Where detailed information on risks is unavailable for the sub-categories, an overall assessment should be given in the shaded row for the risk category as a whole.

Low rating	Other risks	High rating
	10	
	10.1	
	10.2	
	10.3	
	11	
	11.1	
	11.2	
	11.3	
	11.4	
	12	
	12.1	
	12.2	
	12.3	
	12.4	
	13	
	13.1	
	13.2	
	13.3	
	13.4	
	14	
	14.1	
	14.2	
	14.3	
	14.4	

Worksheets A13: Risk analysis, continued

Identified high risks **Worksheet A13.2(a)**

Risk category (a)	Description (b)	Estimated impacts on benefits and costs (c)	Implications (d)	Recommended actions (e)

Worksheets A13: Risk analysis, continued

Relative risk indicators - EXAMPLE **Worksheet A13.2(b)**

The identified, quantifiable risks should be summarised with estimated 95% confidence limits on each risk category (expressed as a % of the impact on TOTAL costs or TOTAL benefits)

Risk category	Cost risk	Benefit risk	Programming risk
1		(R_1=)	
2		(R_2=)	
3		(R_3=)	
4		(R_4=)	
5	(R_5=)		(R_{12}=)
6	(R_6=)		(R_{13}=)
7	(R_7=)		(R_{14}=)
8	(R_8=)		(R_{15}=)
9	(R_9=)		(R_{16}=)
10	(R_{10}=)	(R_{11}=)	(R_{17}=)
Overall relative risk indicators	(RC =)	(RB =)	(RBCR =)

Worksheets A13: Risk analysis, continued

Project cost contingencies **Worksheet A13.3**

Cost item	Expected cost ($)	Contingency ($)
Total expected cost and overall contingency		
Confidence attributable to contingency*		

* This should be expressed as the likelihood that the outturn costs would exceed the total estimated cost including the contingency.