Chapter 4 Simplified procedures for road projects

4.1 Overview

Introduction

This chapter provides simplified procedures (SP) for road projects of lower capital cost or of a routine nature. The simplified procedures condense an evaluation into a few pages.

Application

Guidance on the application of these procedures is found in section 4.2.

For any project that meets the criteria for evaluation, it is feasible to use either the appropriate simplified procedure or the full procedure in chapter 5. However, a choice should be made prior to evaluation, rather than using both methods to see which will give a higher benefit cost ratio.

Each simplified procedure is intended to be a 'stand alone' procedure and can be lifted out of the manual and photocopied for each option being evaluated. Tables in appendix A6 need to be referred to for accident cost savings, table A12.3 for benefit update factors, and appendix A12.4 for target incremental BCR.

In this chapter

In this chapter the following simplified procedures are provided:

4.2 Selecting the procedure

Introduction

Land Transport New Zealand has developed separate simplified procedures for evaluating the different types of road projects.

Selecting the appropriate procedure

If the project is a …	Use
Road renewal, namely: • pavement rehabilitation • drainage renewals • seal widening • preventive maintenance. Geometric improvements are excluded. No cost limit applies.	**SP1**
Structural bridge replacement or renewal, where the: (a) undiscounted cost is ≤ $500,000 and the AADT is ≥ 50 vpd (b) undiscounted cost is ≤ $200,000, the AADT is ≤ 50 vpd and a ford is not a suitable option (c) undiscounted cost of providing a suitable concrete ford is ≥ $30,000 cheaper than providing a replacement bridge and the AADT is ≤ 50 vpd. A decision chart is provided in SP2 to assist selection of the appropriate procedure.	**SP2**
General road improvement, where undiscounted cost is ≤ $500,000.	**SP3**
Seal extension – no cost limit applies.	**SP4**
Isolated intersection improvement where the undiscounted cost is ≤ $250,000.	**SP5**

SP1 Road renewals

Introduction

These procedures (SP1) provide a simplified method of evaluating the economic efficiency of work to be funded under work categories[3]:

- 214: pavement rehabilitation
- 213: drainage renewals
- 231: associated improvements (seal widening)
- 241: preventive maintenance.

To be eligible for funding under these categories, the work must be shown to be the long term, least cost option for the road controlling authority, and must not include geometric improvements. (This requirement is not intended to prevent investment in work that will *coincidentally* give benefit to road users. For example seal widening will usually provide some safety benefits to road users but if the investment is justified on the grounds that it is the most cost effective way to maintain a road shoulder it shall be funded under the seal widening work category).

Under these procedures the present value (PV) cost of the option is determined and compared with the existing maintenance strategy. An existing maintenance strategy commonly includes pavement maintenance work such as dig-outs, reseals, and/or other localised repairs needed to 'hold' the condition of an asset.

The worksheets use a 10% discount rate and 25 year evaluation period. The procedures assume that projects will be completed within the first year and will be in service by the start of Year 2. Where costs are common to both the existing maintenance strategy and the option(s), they are not included in the analysis. All costs shall be exclusive of GST.

Worksheet	Description
1	Evaluation summary
2	Cost of existing maintenance strategy
3	Cost of option

[3] Land Transport NZ's *Programme and funding manual*, chapter 2.

SP1 Road renewals, continued

Explanation for worksheet 1 **Evaluation summary**

Worksheet 1 provides a summary of the general data used for the evaluation as well as the results of the analysis.

The information required is a subset of the information entered into LTP online.

1. Evaluator(s)/reviewer(s): Enter the full name, contact details, name of organisation, office location, etc, of the evaluator(s) and reviewer(s).
2. Project/package details: Provide a general description of the project and package (where relevant), describe the problem being addressed in the existing maintenance strategy, any particular problems and why ongoing maintenance is not viable.
3. Location: A brief description of the project location including:
   - a location/route map
   - a layout plan of the project.
4. Alternatives and options: Describe the do minimum strategy against which options will be compared. Describe the options assessed and how the preferred option will improve on the existing maintenance strategy and reduce or eliminate any problems.
5. Timing: For purposes of the economic efficiency evaluation, the construction start is assumed to be 1 July of the financial year in which the project is submitted for a commitment to funding.
6. Economic efficiency: Enter the timeframe information, the PV cost of the do minimum, the PV cost of the preferred option and the PV total net benefits of the preferred option. Use worksheet 2 to calculate the PV cost of the existing maintenance strategy that will keep the road in service without any improvements. Use worksheet 3 to estimate the PV cost of the preferred project option.
7. PV cost saving: Calculate the cost saving (in PV terms) for the preferred option compared with the do minimum.

SP1 Road renewals, 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 problem to be addressed _____

_____

3 Location

Brief description of location _____

_____

4 Alternatives and options

Describe the do minimum _____

_____

Summarise the options assessed _____

_____

5 Timing

Time zero (assumed construction start date) 1 July

Expected duration of construction (months) _____

6 Economic efficiency

Date economic evaluation completed (mm/yyyy) _____

Base date for costs and benefits 1 July

AADT at time zero _____

Traffic growth rate at time zero (%) _____

PV cost of do minimum (existing maintenance strategy) $ _____ **A**

PV cost of preferred option $ _____ **B**

7 Present value cost saving **(A – B) =** $ _____

Note: The preferred option is justified if the PV cost saving is positive

SP1 Road renewals, continued

Explanation for worksheet 2 **Cost of existing maintenance strategy**

The existing maintenance strategy for pavement rehabilitation will normally include pavement maintenance work and reseal for the whole period of the analysis. For major drainage work, seal widening and preventative maintenance work, the existing maintenance strategy will usually include localised repairs and patching.

1. Historic maintenance cost data: provide the actual (or estimated) maintenance costs for the site for the past 3 years as well as forecasted costs for the current year and future years.
2. Enter the average annual maintenance work costs (including dig-outs not associated with resealing work). Multiply by 9.52 to get the PV for 25 years **(a)**. To convert dollar values from different years to base date values, use the update factors in appendix A12.3.
3. Periodic maintenance costs: For pavement rehabilitation, enter the costs for heavy maintenance and maintenance resealing. Heavy maintenance is activities such as dig-outs and crack bandaging which are often carried out immediately prior to maintenance reseal. For major drainage work, seal widening and preventative maintenance work enter the costs of work required less often than annually. Enter the appropriate SPPWF from table 1 below. The sum of the PV's of periodic maintenance is entered at **(b)**.
4. Add **(a)** + **(b)** to get **A**, the PV cost of the existing maintenance strategy. Transfer the PV of total maintenance cost to **A** on worksheet 1.

Table 1 Single payment present worth factors — for 10 percent discount rate

Year	SPPWF	Year	SPPWF
1	0.91	14	0.26
2	0.83	15	0.24
3	0.75	16	0.22
4	0.68	17	0.20
5	0.62	18	0.18
6	0.56	19	0.16
7	0.51	20	0.15
8	0.47	21	0.14
9	0.42	22	0.12
10	0.39	23	0.11
11	0.35	24	0.10
12	0.32	25	0.09
13	0.29		

SP1 Road renewals, continued

Cost of existing maintenance strategy **Worksheet 2**

1 Historic maintenance cost data (indicate whether assessed or actual)

Maintenance costs for the site over the last 3 years

Year 1 $ _____

Year 2 $ _____

Year 3 $ _____

Maintenance costs for the site this year $ _____

Assessed future maintenance costs $ _____

2 PV of annual maintenance costs

Total = $ _____ × 9.52 = $ _____ **(a)**

3 PV of periodic maintenance costs

Periodic maintenance will be required in the following years:

Year	Type of maintenance	Amount $	SPPWF	Present value

Sum of PV of periodic maintenance $ _____ **(b)**

4 PV of total maintenance costs

(a) + **(b)** = $ _____ **A**

Transfer total to **A** on worksheet 1

SP1 Road renewals, continued

Explanation for worksheet 3 **Cost of the option**

Worksheet 3 is for calculating the PV costs of the proposed option. Cost items to include are: investigation, design, construction, annual maintenance, periodic maintenance (eg, resealing).

1. Enter the cost of the work. The cost of the proposed option is estimated separately on an estimate sheet, which shall be attached to worksheet 3. Multiply the cost of the proposed option by the discount factor 0.91 and enter the cost at **(a)**.
2. Enter the cost of annual routine maintenance for year 1 at **(b)**. As this is assumed to be the year that the proposed option works are carried out, this cost will commonly be the same as that for the existing maintenance strategy, as per step 2 on worksheet 2.
3. Enter the estimated cost of annual maintenance (following completion of the works) and multiply by 8.57 to get the PV for years 2 to 25 inclusive. Enter this cost at **(c)**.
4. Enter the years when periodic maintenance is required, the type of maintenance, the $ amount and the SPPWF. The sum of these gives the PV of periodic maintenance. Enter this at **(c)**. Obtain the SPPWF from table 1.
5. Sum **(a)** + **(b)** + **(c)** + **(d)** to get the PV total costs for the option and enter at **B**. Transfer the PV total costs for the preferred option to **B** on worksheet 1.

SP1 Road renewals, continued

Cost of the option **Worksheet 3**

1 PV of works cost as per attached estimate sheets

$ _____ × 0.91 = $ _____ **(a)**

2 PV of annual maintenance cost in year one

(enter actual dollar amount) = $ _____ **(b)**

3 PV of annual maintenance cost from year 2 – 25 (following completion of works)

$ _____ × 8.57 = $ _____ **(c)**

4 PV of periodic maintenance costs (including second coat seal if appropriate)

Year	Type of maintenance	Amount $	SPPWF	Present value
			Sum of PV of periodic maintenance $	**(d)**

5 PV of total costs of option

(a) + **(b)** + **(c)** + **(d)** = $ _____ **B**

Transfer total for the preferred option to **B** on worksheet 1

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SP2 Structural bridge renewals

Introduction

These procedures (SP2) provide a simplified method for appraising the economic efficiency of replacing a bridge for structural reasons. The benefits analysis focuses on the change in heavy commercial vehicle (HCV) users' costs as a result of the project. Guidance on the application of these procedures is found in section 4.2 and through the decision chart on the following page.

If road improvements are being considered in conjunction with the bridge renewal, then the improvements are to be evaluated separately (using SP3, if applicable – refer section 4.2), when it is confirmed that bridge renewal is the preferred option.

The procedure for analysing structural bridge renewals is somewhat different to other projects, in that all options are identified and costed at the outset, including:

- cost of replacement bridge
- average daily traffic
- viability and cost of a concrete ford
- the HCV users of the bridge
- existence of an alternative route, its length and any necessary upgrade costs
- the cost to repair the bridge to a posted limit of 10 tonnes.

Once this has been done, the decision chart on the following page can be used to determine the appropriate course of action and analysis procedure.

The worksheets use a 10% discount rate and 25 year evaluation period. The procedures assume that funded projects will be completed within the first year and will be in service by the start of year 2. Where costs are common to all the options, they are not included in the analysis. All costs are to be exclusive of GST.

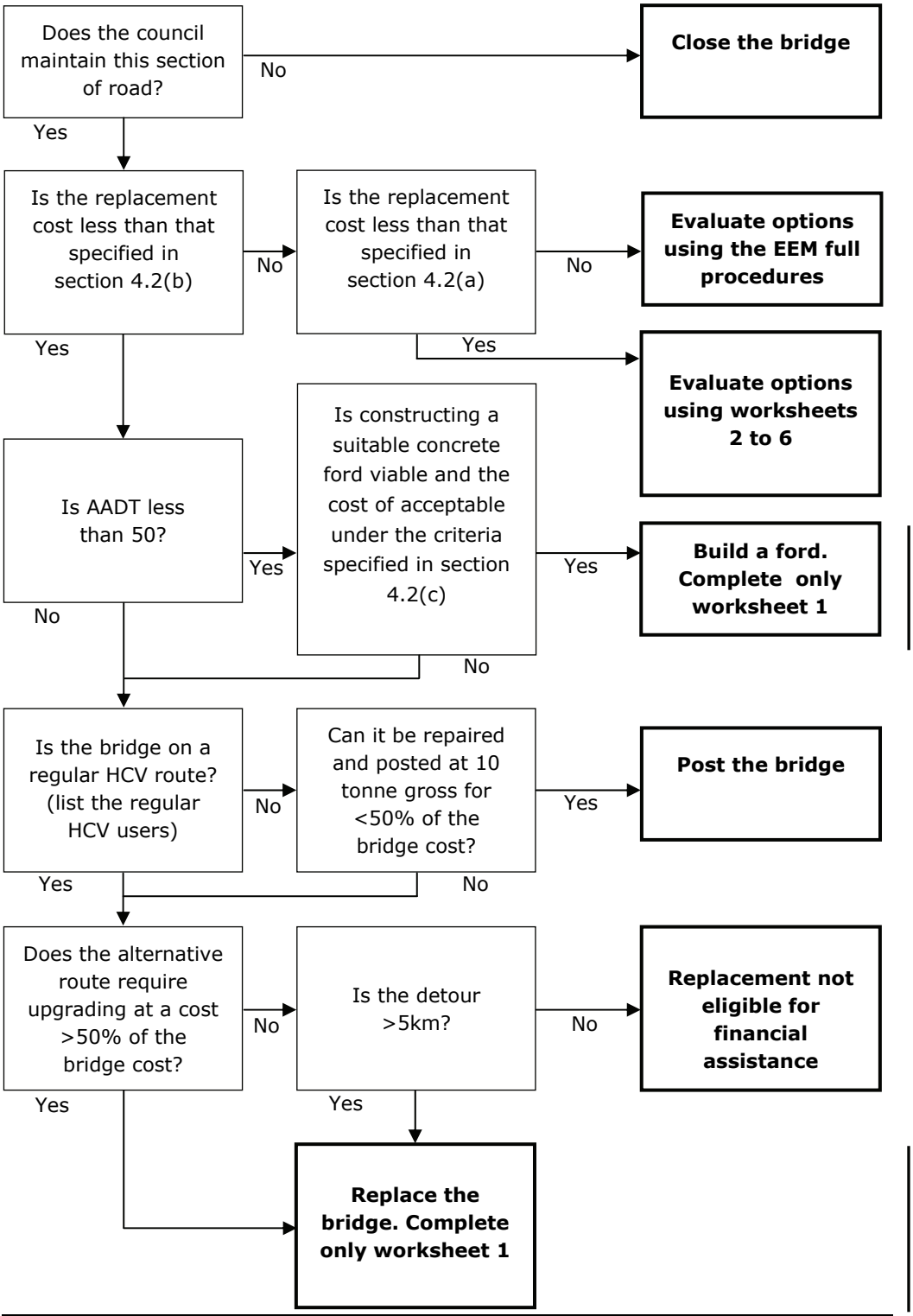
Total bridge failure

This procedure does not allow for the possibility of total bridge failure. If this is a real possibility when certain options are chosen, then account should be taken of the extra costs this would impose on road users multiplied by the probability of failure occurring. The calculation of these probabilities should be undertaken by the same engineers who make the decisions regarding posting the bridge.

Worksheet	Description
1	Building a ford on a low volume road
2	Evaluation summary for bridge renewal
3	Costs of the option(s)
4	HCV user costs when there is an alternative route
5	HCV user costs when there is no alternative route
6	BCR and incremental analysis

SP2 Structural bridge renewals, continued

Decision chart for bridge replacements on low volume roads



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SP2 Structural bridge renewals, continued

Explanation for worksheet 1 **Building a ford on a low volume road**

Worksheet 1 is used to record and summarise the decision to construct a ford on a low volume road (AADT less than 50 vehicles per day) when the cost of the ford is significantly less than a bridge as specified in section 4.2.

The information required is a subset of the information entered into LTP online.

1. Evaluator(s)/reviewer(s): Enter the full name, contact details, name of organisation, office location, etc, of the evaluator(s) and reviewer(s).
2. Project/package details: Provide a general description of the project and package (where relevant), describe the problem with the existing bridge and the problems to be addressed.
3. Location: A brief description of the project location information (as appropriate) including:
   - a location/route map
   - a layout plan of the project.
4. Alternatives and options: Describe the do minimum. The do minimum should be chosen after analysis of low-cost options. The do minimum will not necessarily maintain the capacity of the bridge to carry 100% Class I loading or even to maintain a crossing at all. Describe the options assessed and how building a ford will affect HCVs (eg, will they use the ford or an alternative route?).
5. Timing: For purposes of the economic efficiency evaluation, the construction start is assumed to be 1 July of the financial year in which the project is submitted for a commitment to funding.
6. Economic efficiency: Enter the timeframe information and road and traffic data for the economic efficiency calculation. Identify the existing route length, the length of any available alternative route(s); the proportion of HCVI and HCVII vehicles using the existing bridge; the load factor of the bridge and the existing bridge posting weight limit. If the bridge is on a route regularly used by HCVs provide a (separate) list of common users together with contact details.
7. PV cost of do minimum: Calculate the PV cost of all possible options and select the least PV cost option as the do minimum. The do minimum will not necessarily maintain the capacity of the bridge to carry 100% Class I loading or even maintain a crossing at all. Worksheet 3 may be helpful to this process.
8. PV cost of building a ford: Enter the PV costs of building a suitable ford.
9. PV cost saving: Calculate the cost saving (in PV terms) for the ford compared with the do minimum.

SP2 Structural bridge renewals, continued

Bridge renewal on a low volume road **Worksheet 1**

1 Evaluator(s) _____

Reviewer(s) _____

2 Project/package details

Approved organisation name _____

Project/package name _____

Your reference _____

Project description _____

_____

Describe the problem to be addressed _____

_____

3 Location

Brief description of location _____

_____

4 Alternatives and options

Describe the do minimum _____

_____

Summarise the options assessed _____

_____

5 Timing

Time zero (assumed construction start date) 1 July

Expected duration of construction (months) _____

6 Economic efficiency

Date economic evaluation completed (mm/yyyy) _____

Base date for costs and benefits 1 July

AADT at time zero _____

Traffic growth rate at time zero (%) _____

%HCVI _____ Number = _____ Existing bridge posting weight limit _____ % Class I

%HCVII _____ Number = _____ Existing route length = _____ km

Attach list of regular HCV users with contact details

Load factor _____ % Is alternative route available ☐ Yes ☐ No

If yes, length of alternative = _____ km

7 PV cost of do minimum $ _____ **A**

8 PV cost of building the chosen option $ _____ **B**

9 Present value cost saving **(A – B) =** $ _____

Note: The ford is justified if the PV cost saving is positive

SP2 Structural bridge renewals, continued

Explanation for worksheet 2 **Evaluation summary for bridge renewal**

Worksheet 2 provides a summary of the general data used for the evaluation where a decision is for a structural bridge renewal.

1. Evaluator(s)/reviewer(s): Enter the full name, contact details, name of organisation, office location, etc, of the evaluator(s) and reviewer(s).
2. Project/package details: Provide a general description of the project and package (where relevant), describe the problem with the existing bridge and the problems to be addressed.
3. Location: A brief description of the project location including:
   - a location/route map
   - a layout plan of the project.
4. Alternatives and options: Describe the do minimum. The do minimum should be chosen after analysis of low-cost options. The do minimum will not necessarily maintain the capacity of the bridge to carry 100% Class I loading or even maintain a crossing at all. Describe the options assessed and how the preferred option will affect traffic, particularly HCVs.
5. Timing: For purposes of the economic efficiency evaluation, the construction start is assumed to be 1 July of the financial year in which the project is submitted for a commitment to funding..
6. Economic efficiency: Enter the timeframe information and road and traffic data for the economic efficiency calculation. Identify the existing route length, the length of any available alternative route(s); the proportion of HCVI and HCVII vehicles using the existing bridge; the load factor of the bridge and the existing bridge posting weight limit. If the bridge is on a route regularly used by HCVs provide a (separate) list of common users together with contact details.
7. PV cost of do minimum: Use worksheet 3 to calculate the PV cost of all possible options and select the least cost option as the do minimum.
8. PV cost of preferred option: Use worksheet 3 to estimate the PV cost of the preferred option.
9. Enter the economic evaluation data from worksheet 4 or 5. To convert the road user costs to base date values use the update factors in appendix A12.3. If the road user costs of the do minimum are less than the road user costs of the chosen option, then the option should be abandoned.
10. The national BCR is calculated by dividing the PV of the net benefits (PV benefits of the do minimum subtracted from the PV benefits of the option) by PV of the net costs (PV costs of the do minimum subtracted from the PV costs of the option).
11. First year rate of return (FYRR) is calculated as the benefits in the first full year following completion divided by the project costs. The first year benefits are calculated by dividing the totals at **Y** and **Z** by the BDF from table 1 of worksheet 4. Then multiply by 0.91 to get the present value.

SP2 Structural bridge renewals, continued

Evaluation summary for bridge renewal **Worksheet 2**

1 Evaluator(s) _____

Reviewer(s) _____

2 Project/package details

Approved organisation name _____

Project/package name _____

Your reference _____

Project description _____

Describe the problem to be addressed _____

_____

3 Location

Brief description of location _____

_____

4 Alternatives and options

Describe the do minimum _____

_____

Summarise the options assessed _____

5 Timing

Time zero (assumed construction start date) 1 July

Expected duration of construction (months) _____

6 Economic efficiency

Date economic evaluation completed (mm/yyyy) _____

Base date for costs and benefits 1 July

AADT at time zero _____

Traffic growth rate at time zero (%) _____

%HCVI _____ Number = _____ Existing bridge posted weight limit _____ % Class I

%HCVII _____ Number = _____ Existing route length = _____ km

Attach list of regular HCV users with contact details

Load factor _____ % Is alternative route available ☐ Yes ☐ No

If yes, length of alternative = _____ km

7 PV cost of do minimum $ _____ **A**

8 PV cost of the preferred option $ _____ **B**

9 Data from worksheet 4 or 5

HCV user costs of do minimum $ _____ **C** x Update factor ^{VOC} _____ = $ _____ **Y**

HCV user costs of option $ _____ **D** x Update factor ^{VOC} _____ = $ _____ **Z**

10 $BCR_N = \frac{\text{PV net benefits}}{\text{PV net costs}} = \frac{\mathbf{Y} - \mathbf{Z}}{\mathbf{B} - \mathbf{A}} = \_\_\_\_ =$ _____

11 $FYRR = \frac{\text{PV 1st year benefits}}{\text{PV net costs}} = \frac{[(\mathbf{Y} - \mathbf{Z}) / BDF] \times 0.91}{\mathbf{B} - \mathbf{A}} =$ _____

SP2 Structural bridge renewals, continued

Explanation for worksheet 3 **Cost of the option(s)**

Worksheet 3 is used to calculate the costs of the different options. At the top of the worksheet, circle the option being evaluated. A separate Worksheet 3 is required for each option evaluated. To convert dollar values from different years to base date values, use the update factors in appendix A12.3.

1. Circle the option being considered.
2. Enter the capital cost (including professional services for design and supervision) of the proposed option. The cost is estimated separately on an estimate sheet, which should be attached to this worksheet. Multiply the cost by the discount factor 0.91 and enter at **(a)**.
3. Enter the cost of maintenance for year 1 **(b)**. As this is assumed to be the year that the proposed option works are carried out, this cost will commonly be the same as that for the existing maintenance strategy, as per step 2 on worksheet 2.
4. Enter the cost for annual maintenance and inspections following completion of the works. Multiply by 8.57 to get the PV of annual maintenance costs **(c)** for years 2 to 25 inclusive.
5. Enter the costs of periodic maintenance. Determine which years this maintenance will be required (if at all) and enter the year, estimated cost and SPPWF (from table 1 below). Calculate the present value (estimated cost × SPPWF) for each cost and sum these to obtain the PV of the total periodic maintenance cost **(d)**.
6. Where an alternative route is being considered, the PV cost of additional maintenance required for the road due to extra HCV trips should be calculated. Enter additional annual maintenance costs for the route and multiply by 9.52 to get the PV costs for years 1 to 25 inclusive **(e)**. If the option is to close the existing bridge then **(e)** will be the cost of the option.
7. Sum all of the PV costs for the option **(a)** + **(b)** + **(c)** + **(d)** + **(e)** to determine the PV total costs for each option. Once the costs of all viable options have been calculated, the lowest cost option is chosen as the do minimum. Transfer total to **A** (if do minimum) or **B** (if preferred option) on worksheet 1.

Table 1 Single payment present worth factors — for 10 percent discount rate

Year	SPPWF	Year	SPPWF
1	0.91	14	0.26
2	0.83	15	0.24
3	0.75	16	0.22
4	0.68	17	0.20
5	0.62	18	0.18
6	0.56	19	0.16
7	0.51	20	0.15
8	0.47	21	0.14
9	0.42	22	0.12
10	0.39	23	0.11
11	0.35	24	0.10
12	0.32	25	0.09
13	0.29		

SP2 Structural bridge renewals, continued

Costs of the option(s) **Worksheet 3**

1 Option (circle option being considered)

posting/strengthening/new bridge/ford/culvert/alternative route

2 PV of estimated cost of proposed work (as per attached estimate sheets)

$ _____ × 0.91 = $ _____ **(a)**

3 PV of maintenance cost in year 1 = $ _____ **(b)**

4 PV of annual maintenance and inspection costs following the work

(years 2 to 25 inclusive) $ _____ × 8.57 = $ _____ **(c)**

5 PV of periodic maintenance costs

Year	Type of maintenance	Amount $	SPPWF	Present value
			Sum of PV of periodic maintenance costs = $		**(d)**

6 PV cost of additional annual maintenance (due to extra HCV trips)

$ _____ x 9.52 = $ _____ **(e)**

7 PV of total costs of option

PV total costs (a) + (b) + (c) + (d) + (e) = $ _____ **A** or **B**

Transfer total to **A** (if do minimum) or to **B** (if preferred option) on worksheet 1. If the preferred option is to close the bridge, then transfer **(e)** to worksheet 1

SP2 Structural bridge renewals, continued

Explanation for worksheet 4 HCV user costs when there is an alternative route

Worksheet 4 is used for calculating the HCV road user costs for the various options when there is an alternative route. If posting the bridge is the do minimum, then the HCV users will either choose to:

(a) use the existing bridge with load restriction and make more trips in lightly loaded vehicles, or

(b) use the longer alternative route with fully loaded vehicles.

The HCV users operating costs for both alternatives should be calculated and the lowest HCV user cost used in the benefit cost analysis. If bridge is closed and an alternative route takes all diverted traffic, then the additional VOC, travel time and accident costs for the whole traffic stream are calculated. The additional costs per kilometre, including an adjustment for CO_2 emission costs, have been standardised for the HCV user cost calculations. The values are already included in the worksheet.

1. Circle the option being considered.
2. Calculate the HCV user costs for the existing route at _____% Class I loading by entering the information indicated below. Multiply across the lines to get the annual user costs for HCVI and HCVII. Sum these values to get the total HCV user costs **(a)**. Multiply **(a)** by the appropriate bridge discount factor (BDF in table 1) to give the PV of HCV user costs for 25 years **(b)**.

   Required information:

L	length of existing route in kilometres (between intersections with the alternative route). A survey of local transport operators and businesses will provide data to allow an estimate of the trip lengths for HCVs on trips that cross the bridge.
LA	length of alternative route in kilometres
ADT HCVI	the average daily tally of HCVI on the existing route
ADT HCVII	the average daily tally of HCVII on the existing route
LF	HCV load factor (% of fully loaded vehicles). Use 70% unless better data is available
FCF	freight cost factor (from table 2) used to calculate increased costs due to extra trips required by posting a load restriction on a highway

3. Repeat step 1 for the option of the alternative longer route, to derive values for **(c)** and **(d)**.
4. Repeat step 1 for the option of the existing route at 100% Class I loading for **(e)** and **(f)**.
5. Where the option to maintain the existing route at 100% Class I loading requires downgrading the bridge and constructing a ford, the additional user costs of a ford must be calculated and added to **(f)**. Repeat the process for step 1 for the option of a ford, to derive the values for **(g)** and **(h)**. To get the total HCV user costs for the option add **(f)** and **(h)** to get **(j)**.
6. Transfer the HCV user costs for the do minimum to **A** and preferred option to **B** on worksheet 2.

Table 1 Bridge renewal discount factors (BDF) for years 1 to 25 inclusive

HCV growth rate	0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
Discount factor BDF	9.25	9.90	10.28	10.66	11.04	11.42	11.80	12.17	12.55

Table 2 Freight cost factors

% Class I	HCVI	HCVII
100	1.00	1.00
90	1.18	1.22
80	1.44	1.57
70	1.85	2.22
60	2.60	3.67
50	4.33	11.00

SP2 Structural bridge renewals, continued

HCV user costs when there is an alternative route **Worksheet 4**

1 Option (circle option being considered)

existing route at _____ % Class I/alternative longer route/existing route at 100% Class I (bridge retained)/existing route at 100% Class I (bridge downgraded) with a ford crossing

2 The existing route at _____ % Class I loading

L _____ x ADT HCVI _____ x LF _____ x FCF _____ x $1.30 x 365 = $_____

L _____ x ADT HCVII _____ x LF _____ x FCF _____ x $1.95 x 365 = $_____

Sum of HCVI and HCVII user costs = $_____ **(a)**

PV total HCV user costs for 25 years = $ _____ **(a)** x _____ BDF = $_____ **(b)**

3 The alternative longer route

LA _____ x ADT HCVI _____ x LF _____ x FCF* _____ x $1.30 x 365 = $_____

LA _____ x ADT HCVII _____ x LF _____ x FCF* _____ x $1.95 x 365 = $_____

Sum of HCVI and HCVII user costs = $_____ **(c)**

PV total HCV user costs for 25 years = $ _____ **(c)** x _____ BDF = $_____ **(d)**

*FCF will normally be 1.0 for the alternative route – if not use value from FCF table 2.

4 The existing route at 100% Class I loading (bridge retained)

L _____ x ADT HCVI _____ x LF _____ x FCF _____ x 1.30 x 365 = $_____

L _____ x ADT HCVII _____ x LF _____ x FCF _____ x 1.95 x 365 = $_____

Sum of HCVI and HCVII user costs = $_____ **(e)**

PV total HCV user costs for 25 years = $ _____ **(e)** x _____ BDF =$_____ **(f)**

5 The existing route at 100% Class I loading (bridge downgraded and a ford constructed)

ADT HCVI _____ x LF _____ x $1.10 x 365 = $_____

ADT HCVII _____ x LF _____ x $1.75 x 365 = $_____

Sum of HCVI and HCVII user costs = $_____ **(g)**

PV user costs for using ford for 25 years = $ _____ **(g)** x _____ BDF = $_____ **(h)**

PV total HCV user costs for existing route at 100% class I loading where a ford is provided:

Sum of HCVI and HCVII user costs for existing route **(f)** + using ford **(h)** = $_____ **(j)**

6 Transfer **(b)**, **(d)**, **(f)** or **(j)** to **A** (if do minimum) or to **B** (if preferred option) on worksheet 2, as appropriate.

SP2 Structural bridge renewals, continued

Explanation for worksheet 5 **HCV user costs when there is no alternative route**

Worksheet 5 provides a method for calculating HCV road user costs when no alternative route is available. In this situation, the HCV user costs for bridge crossings should be calculated for the distance between the origin and destination of the trips.

1. Circle the option being considered.
2. Calculate the HCV user costs for the existing route at _____% Class I loading as follows by entering the information indicated below. Multiply across the lines to get the annual user costs for HCVI and HCVII. Sum these two values to get the total HCV user costs **(a)**. Multiply the total in **(a)** by the appropriate bridge discount factor (BDF in table 1 of worksheet 4) to give the PV of HCV user costs for 25 years **(b)**.

   Required information:

L	length of existing route in kilometres (between intersections with the alternative route). A survey of local transport operators and businesses will provide data to allow an estimate of the trip lengths for HCVs on trips that cross the bridge.
ADT HCVI	the average daily tally of HCVI on the existing route
ADT HCVII	the average daily tally of HCVII on the existing route
LF	load factor (the percentage of fully loaded vehicles) for HCVs. Use 0.7 (70%) unless better data is available
FCF	freight cost factor (from table 2 of worksheet 4) used to calculate increased costs due to extra trips required by posting a load restriction on a highway

3. Repeat step 1 for the option of the existing route at 100% Class I loading (bridge retained), to derive the values for **(c)** and **(d)**.
4. Where the option to maintain the existing route at 100% Class I loading requires downgrading the bridge and constructing a ford, the additional user costs of a ford must be calculated and added to **(d)** to get the total HCV user costs for the option **(g)**.
5. Transfer the HCV user costs for the selected do minimum to **C** and preferred option to **D** on worksheet 2.

SP2 Structural bridge renewals, continued

HCV user costs when there is no alternative route **Worksheet 5**

1 Option (circle option being considered)

existing route at _____% Class I loading/existing route at 100% class I loading (bridge retained)/ existing route at 100% class I loading (bridge downgraded and ford constructed)

2 The existing route at _____ % Class I loading

L _____ x ADT HCVI _____ x LF[1] _____ x FCF _____ x $1.30 x 365 = $_____

L _____ x ADT HCVII _____ x LF[1] _____ x FCF _____ x $1.95 x 365 = $_____

Sum of HCVI and HCVII user costs = $_____ **(a)**

PV total HCV user costs for 25 years = $ _____ **(a)** x _____ BDF = $_____ **(b)**

[1]LF is likely to be greater than 0.7 when there is not alternative route.

3 The existing route at 100% Class I loading (bridge retained)

L _____ x ADT HCVI _____ x LF _____ x 1.30 x 365 = $_____

L _____ x ADT HCVII _____ x LF _____ x 1.95 x 365 = $_____

Sum of HCVI and HCVII user costs = $_____ **(c)**

PV total HCV user costs for 25 years = $ _____ **(c)** x _____ BDF =$_____ **(d)**

4 The existing route at 100% Class I loading (bridge downgraded and a ford constructed)

ADT HCVI _____ x LF _____ x $1.10 x 365 = $_____

ADT HCVII _____ x LF _____ x $1.75 x 365 = $_____

Sum of HCVI and HCVII user costs = $_____ **(e)**

PV user costs for using ford for 25 years = $ _____ **(e)** x _____ BDF = $_____ **(f)**

PV total HCV user costs for existing route at 100% class I loading where a ford is provided:

Sum of HCVI and HCVII user costs for existing route **(d)** + using ford **(f)** = $_____ **(g)**

5 Transfer **(b)**, **(d)** or **(g)** to **A** (if do minimum) or to **B** (if preferred option) on worksheet 2, as appropriate.

SP2 Structural bridge renewals, continued

Explanation for worksheet 6 **BCR and incremental analysis**

Cost benefit analysis

1. Under benefits, enter the PVs for the benefits for the do minimum and for each option. Then subtract the benefits for the options from the benefits for the do minimum to get the net benefits of each option.
2. Under costs, enter the PVs of the capital and maintenance costs for the do minimum and each option. Subtract the PV costs for the do minimum from the costs for the options to get the net costs of each option.
3. Calculate the national BCR by dividing the net benefits by the net costs.

Incremental analysis

1. Select the appropriate target incremental BCR from appendix A12.4.
2. Rank the options in order of increasing cost.
3. Compare the lowest cost option with the next higher cost option to calculate the incremental BCR.
4. If the incremental BCR is less than the target incremental BCR, discard the second option in favour of the first and compare the first option with the next higher cost option.
5. If the incremental BCR is greater than the target incremental BCR, the second option becomes the basis for comparison against the next higher cost option.
6. Repeat the procedure until no higher cost options are available that have an incremental BCR greater than the target incremental BCR. The highest cost option with an incremental BCR greater than the target incremental BCR is generally considered as the preferred option.

SP2 Structural bridge renewals, continued

BCR and incremental analysis **Worksheet 6**

Time zero _____

Base date _____

BCR_N	**Do minimum**	**Option A**	**Option B**	**Option C**	**Option A**	**Option B**	**Option C**
	PV of benefits as calculated				**PV of net benefits**		
HCV vehicle operating costs							
Other road user costs when bridge is closed							
PV total net benefits							
	PV of costs as calculated				**PV of net costs**		
Capital costs							
Maintenance costs							
PV total net costs							
BCR_N							

Target incremental BCR (from appendix A12.4) _____

Base option for comparison			**Next higher cost option**			**Incremental analysis**		
Option	**Total costs (1)**	**Total benefits (2)**	**Option**	**Total costs (3)**	**Total benefits (4)**	**Incremental costs (5)=(3)-(1)**	**Incremental benefits (6)=(4)-(2)**	**Incremental BCR_N (7)=(6)/(5)**

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SP3 General road improvements

Introduction

These procedures (SP3) provide a simplified method of evaluating the economic costs and benefits of general road improvements, including: road reconstruction, new roads and structures. They specifically exclude seal extension work (SP4), bridge renewals (SP2) and pavement rehabilitation (SP1). The method is for the evaluation of projects that have a capital cost less than or equal to the limits specified in section 4.2.

The procedures are designed to consider one option at a time. All suitable options for the proposed works should be considered in order to select the optimal solution. In most situations this will involve incremental analysis of the benefits and costs of the different options analysed. A description of all options considered should be described in worksheet 1 and included in the incremental analysis; for all other worksheets, only the details for the preferred option needs to be included.

To use the worksheets it is necessary to determine the traffic growth rate for the project. This can be done either by analysing the traffic count data (for at least the last 5 years and preferably for the last 10 years) or by using the default values in appendix A2.5.

The worksheets use a 10% discount rate and 25 year evaluation period. The procedure assumes that funded projects will be completed in the first year and will be in service by the start of year 2. Where costs are common to the do minimum and the options, they are not included in the analysis. All costs are to be exclusive of GST.

Worksheet	Description
1	Evaluation summary
2	Cost of do minimum
3	Cost of the option(s)
4	Travel time cost savings
5	Vehicle operating cost savings
6	Accident cost savings
7	BCR and incremental analysis

SP3 General road improvements, continued

Explanation for worksheet 1 **Evaluation summary**

Worksheet 1 provides a summary of the general data used for the evaluation as well as the results of the analysis.

The information required is a subset of the information entered into LTP online.

1. Evaluator(s)/reviewer(s): Enter the full name, contact details, name of organisation, office location, etc, of the evaluator(s) and reviewer(s).
2. Project/package details: Provide a general description of the project and package (where relevant), describe the problems with the existing road section and the problems to be addressed.
3. Location: A brief description of the project location including:
   - a location/route map
   - a layout plan of the project.
4. Alternatives and options: Describe the do minimum that is usually the least cost option to maintain the road section in an unimproved state. Describe the options assessed and how the preferred option will improve the road section.
5. Timing: The construction start is assumed to be 1 July of the financial year in which the project is submitted for a commitment to funding.
6. Economic efficiency: Enter the timeframe information, the road and traffic data, identify the existing and predicted traffic speed, the existing and predicted roughness (IRI or NAASRA), and the length of road before and after works.
7. PV cost of do minimum: Use worksheet 2 to calculate the PV cost of the do minimum. This should be the lowest cost option that will keep the road in service. It will provide no improvements.
8. PV cost of the preferred option: Use worksheet 3 to estimate the preferred option PV cost.
9. Enter the benefits values from worksheets 4 (travel time savings), 5 (vehicle operating cost savings) and 6 (accident cost savings). To bring the benefits up to the base date values, use the appropriate update factors supplied in appendix A12.3. The base VOC incorporates the CO_2 costs and no separate adjustment is required.
10. The national benefit cost ratio is calculated by dividing the PV of the net benefits (PV benefits of the do minimum subtracted from the PV benefits of the option) by PV of the net costs (PV costs of the do minimum subtracted from the PV costs of the option).
11. First year rate of return (FYRR) is calculated as the benefits in the first full year following completion divided by the project costs. The first year benefits are calculated by dividing the totals at **W**, **Y** and **Z** by the discount factors used on worksheets 4, 5 and 6 respectively, and then multiplying by 0.91 to get the present value.

Note: the discount factor for VOCs and travel time (see explanation for worksheets 4 and 5) is different to the discount factor for accidents (see explanation for worksheet 6).

SP3 General road improvements, 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 problem to be addressed _____

3 Location

Brief description of location _____

_____

4 Alternatives and options

Describe the do minimum _____

_____

Summarise the options assessed _____

_____

5 Timing

Time zero (assumed construction start date) 1 July

Expected duration of construction (months) _____

6 Economic efficiency

Date economic evaluation completed (mm/yyyy) _____

Base date for costs and benefits 1 July

AADT at time zero _____

Traffic growth rate at time zero (%) _____

Existing roughness _____ IRI or NAASRA Existing traffic speed _____ km/h

Predicted roughness _____ IRI or NAASRA Predicted traffic speed _____ km/h

Length of road before works _____ km

Length of road after works _____ km

7 PV cost of do minimum $ _____ **A**

8 PV cost of the preferred option $ _____ **B**

9 Benefit values from worksheet 4, 5 or 6

PV travel time cost savings $ _____ **C** x Update factor ^{TTC} _____ = $ _____ **W**

PV VOC and CO_2 savings $ _____ **D** x Update factor ^{VOC} _____ = $ _____ **Y**

PV accident cost savings $ _____ **E** x Update factor ^{AC} _____ = $ _____ **Z**

10 $BCR_N = \frac{\text{PV net benefits}}{\text{PV net costs}} = \frac{\mathbf{W} + \mathbf{Y} + \mathbf{Z}}{\mathbf{B} - \mathbf{A}} = \_\_\_\_ =$ _____

11 $FYRR = \frac{\text{PV 1st year benefits}}{\text{PV net costs}} = \frac{[(\mathbf{W} + \mathbf{Y}) / DF^{VOC} + (\mathbf{Z} / DF^{AC})] \times 0.91}{\mathbf{B} - \mathbf{A}} =$ _____ %

SP3 General road improvements, continued

Explanation for worksheet 2 **Costs of do minimum**

Worksheet 2 is used to calculate the PV cost of the do minimum. The do minimum is the minimum level of expenditure necessary to keep a road open and generally consists of maintenance work.

1. The annual and periodic maintenance costs should be obtained from maintenance records and resealing records. If pavement rehabilitation is proposed at some future date as part of the do minimum, then:
   (a) it must be tested against the option of continued pavement maintenance in order to establish that it is the true do minimum; and
   (b) only the costs of basic sealed smoothing work shall be used in the analysis.
2. Calculate the PV of annual maintenance costs **(a)** for the do minimum by multiplying the annual cost by the discount factor of 9.52.
3. Schedule any periodic maintenance, according to the year in which this work is expected to be undertaken. Apply the appropriate single payment present worth factor (SPPWF) from table 1 below to determine the PV at time zero. Sum the PV of the periodic costs to determine the PV of total periodic maintenance costs **(b)**.
4. Calculate the PV total costs of the do minimum by adding **(a)** + **(b)**. Transfer the total to **A** on worksheet 1.

Table 1 Single payment present worth factors (for 10% discount rate)

Year	SPPWF	Year	SPPWF
1	0.91	14	0.26
2	0.83	15	0.24
3	0.75	16	0.22
4	0.68	17	0.20
5	0.62	18	0.18
6	0.56	19	0.16
7	0.51	20	0.15
8	0.47	21	0.14
9	0.42	22	0.12
10	0.39	23	0.11
11	0.35	24	0.10
12	0.32	25	0.09
13	0.29		

SP3 General road improvements, continued

Cost of do minimum **Worksheet 2**

1 Historic maintenance cost data (indicate whether assessed or actual)

Maintenance costs for the site over the last 3 years

Year 1 $ _____

Year 2 $ _____

Year 3 $ _____

Maintenance costs for the site this year $ _____

Assessed future maintenance costs $ _____

2 PV of annual maintenance costs

Total = $ _____ × 9.52 = $ _____ **(a)**

3 PV of periodic maintenance costs

Periodic maintenance will be required in the following years:

Year	Type of maintenance	Amount $	SPPWF	Present value
			Sum of PV of periodic maintenance costs $	**(b)**

4 PV of total maintenance costs

(a) + (b) = $ _____ **A**

Transfer total to **A** on worksheet 1

SP3 General road improvements, continued

Explanation for worksheet 3 **Cost of the option(s)**

Worksheet 3 is used to calculate the PV costs of the different options. A separate Worksheet 3 is required for each option evaluated. To convert dollar values from different years to base date values, use the update factors in appendix A12.3.

1. Enter the capital cost (including professional services for design and supervision) of the proposed option. The cost is estimated separately on an estimate sheet, which should be attached to this worksheet. Multiply the cost by the discount factor 0.91 and enter at **(a)**.
2. Enter the cost of maintenance for year 1 at **(b)**. As this is assumed to be the year that the proposed option works are carried out, this cost will commonly be the same as that for the existing maintenance strategy, as per step 2 on worksheet 2.
3. Enter the cost for annual maintenance and inspections following completion of the works. Multiply by 8.57 to get the PV of annual maintenance costs **(c)** for years 2 to 25 inclusive.
4. Enter the costs of periodic maintenance. Determine which years this maintenance will be required (if at all) and enter the year, estimated cost and SPPWF (from table 1 of worksheet 2). Calculate the present value (estimated cost $\times$ SPPWF) for each cost and sum these to obtain the PV of the total periodic maintenance cost **(d)**.
5. The annual costs (for years 2 to 25) associated with the improved road section, but not maintaining the capital assets, are specified and multiplied by the discount factor of 8.57 to get **(e)**.
6. The sum of **(a)** + **(b)** + **(c)** + **(d)** + **(e)** gives the PV total cost of the option, **B**. Transfer **B** for the preferred option to **B** on worksheet 1.

SP3 General road improvements, continued

Cost of the option(s) **Worksheet 3**

1 PV of estimated cost of proposed work (as per attached estimate sheets)

$ _____ × 0.91 = $ _____ **(a)**

2 PV of maintenance cost in year 1 = $ _____ **(b)**

3 PV of annual maintenance and inspection costs following the work

(years 2 to 25 inclusive) $ _____ × 8.57 = $ _____ **(c)**

4 PV of periodic maintenance costs

Year	Type of maintenance	Amount $	SPPWF	Present value
			Sum of PV of periodic maintenance costs = $	**(d)**

5 PV cost of additional annual maintenance

$ _____ x 8.57 = $ _____ **(e)**

6 PV of total costs of option

PV total costs (a) + (b) + (c) + (d) + (e) = $ _____ **B**

Transfer PV of total costs for the preferred option to **B** on worksheet 1

SP3 General road improvements, continued

Explanation for worksheet 4 **Travel time cost savings**

Worksheet 4 is used for calculating travel time cost savings.

1. Circle the road type.
2. Enter the data required to complete the travel time cost savings calculations. Default values for travel time costs are found in the table 1 below.
3. Calculate the annual travel time costs for the do minimum using the formula provided.
4. Calculate the annual travel time costs for the option using the formula provided.
5. The vehicle speed and route length will be the same for both the do minimum and the project option if the work does not either shorten the route or increase vehicle speeds.
6. Calculate the annual travel time cost savings by subtracting the travel time costs for the option **(b)** from the do minimum travel time costs **(a)** to get **(c)**.
7. Determine the PV of the travel time cost savings, **C** by multiplying **(c)** by the appropriate discount factor from table 2 below. Transfer the PV of travel time cost savings, **C** for the preferred option to worksheet 1.

Table 1 Travel time cost for standard traffic mixes for all periods combined (July 2002)

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

Table 2 Travel time cost discount factors (DF^{TTC}) for different traffic growth rates for years 2 to 25 inclusive

Traffic growth rate	0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
Discount factor (DF^{TTC})	8.57	8.95	9.32	9.70	10.07	10.45	10.83	11.20	11.58

SP3 General road improvements, continued

Travel time cost savings **Worksheet 4**

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

2 Travel time data

AADT (or the traffic volumes affected by the improvement) _____

Travel time cost, TTC $ _____

	Do minimum		Option	
Length of route in km	L^{dm}		L^{opt}	
Mean vehicle speed	VS^{dm}		VS^{opt}	

3 Annual travel time costs for the do minimum

$$\frac{AADT \times 365 \times L^{dm} \times TTC}{VS^{dm}} = \$ \_\_\_\_\_ \textbf{(a)}$$

4 Annual travel time costs for the option

$$\frac{AADT \times 365 \times L^{opt} \times TTC}{VS^{opt}} = \$ \_\_\_\_\_ \textbf{(b)}$$

5 Value of annual travel time cost savings **(a)** – **(b)** = $ _____ **(c)**

6 PV of travel time cost savings **(c)** x DF^{TTC} = $ _____ **C**

Transfer PV of travel time cost savings, **C** for the preferred option to **C** on worksheet 1

SP3 General road improvements, continued

Explanation for worksheet 5 **Vehicle operating cost savings**

Worksheet 5 is used for calculating vehicle operating cost (VOC) savings.

1. Enter the base data required for analysis of VOC savings. Table 1 provides the base VOCs (CB) in cents/km for different gradients and mean vehicle speeds, while table 2 provides roughness costs (CR) in cents/km for different road roughness.
2. Calculate the annual VOCs **(a)** for the do minimum using the formula provided.
3. Calculate the annual VOCs **(b)** for the option using the formula provided.
4. Calculate the annual VOC savings by subtracting the VOCs for the option **(b)** from the do minimum VOCs **(a)** to get **(c)**.
5. Determine the PV of the annual VOC savings **D**, multiplying **(c)** by the appropriate discount factor from table 3. Transfer the PV of annual VOC savings, **D** for the preferred option to **D** on worksheet 1.

Table 1 Base vehicle operating costs (CB) including CO_2 - in cents/km (July 2002)

% gradient	**Mean vehicle speed** (over length of route)				
	0–30 km/h	**31-50 km/h**	**51-70 km/h**	**71-90 km/h**	**91-105 km/h**
0	24.1	20.1	19.7	20.3	21.3
1 to 3	24.4	20.4	19.9	20.6	21.6
4 to 6	25.3	21.5	21.0	21.7	22.7
7 to 9	26.7	23.2	22.9	23.6	24.7
10 to 12	28.5	25.3	25.2	26.2	27.4

Table 2 Roughness costs (CR) in cents/km (July 2002)

Unsealed road roughness before sealing can be assumed to be 6.5 IRI (≈170 NAASRA counts) and 2.5 IRI (≈66 NAASRA counts) after sealing. If values higher than 6.5 IRI (or 170 NAASRA) for initial roughness of unsealed roads are used these need to be substantiated.

IRI m/km	NAASRA counts/ km	CR cents/km urban	CR cents/km rural	IRI m/km	NAASRA counts/ km	CR cents/km urban	CR cents/km rural
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

Table 3 VOC discount factors (DF^{VOC}) for different traffic growth rates for years 2 to 25 inclusive

Growth rate	0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
Discount factor (DF^{VOC})	8.57	8.95	9.32	9.70	10.07	10.45	10.83	11.20	11.58

SP3 General road improvements, continued

Vehicle operating cost savings **Worksheet 5**

1 Base costs

Traffic growth rate (per annum) _____ %

AADT (or the traffic volumes affected by the improvement) _____

	Do minimum		Option	
Length of route in km	L^{dm}		L^{opt}	
Roughness (IRI/NAASRA)				
Roughness cost	CR^{dm}		CR^{opt}	
Mean vehicle speed	VS^{dm}		VS^{opt}	
Gradient				
Base cost	CB^{dm}		CB^{opt}	

2 Annual vehicle operating cost for the do minimum

$$\frac{L^{dm} \times (CR^{dm} + CB^{dm}) \times AADT \times 365}{100} = \$ \_\_\_\_\_ \textbf{(a)}$$

3 Annual vehicle operating cost for the option

$$\frac{L^{opt} \times (CR^{opt} + CB^{opt}) \times AADT \times 365}{100} = \$ \_\_\_\_\_ \textbf{(b)}$$

4 Value of annual vehicle operating cost savings **(a)** – **(b)** = $ _____ **(c)**

5 PV of vehicle operating cost savings **(c)** x DF^{VOC} = $ _____ **D**

Transfer PV of vehicle operating cost savings, **D** for the preferred option to **D** on worksheet 1

SP3 General road improvements, continued

Explanation for worksheet 6 **Accident cost savings**

These simplified procedures are 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 worksheet 1 as total **E**.

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)**.
9. 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)**.
10. 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)**.
11. 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)**.
12. 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)**.
13. Calculate the annual accident cost savings by subtracting the values in **(26)** from **(17)**. Multiply the annual accident cost savings **(27)** – or the total from the accident rate or weighted accident analysis – by the discount factor in table 1 for the appropriate speed limit and traffic growth rate to determine the PV accident cost savings. Transfer this total, **E** for the preferred option to worksheet 1.

Table 1 Accident cost discount factor (DFAC) for different traffic growth rates and speed limits for years 2 to 25 inclusive

Traffic growth rate	0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
50 and 60 km/h	6.31	6.69	7.07	7.44	7.82	8.19	8.57	8.95	9.32
≥ 70 km/h	7.82	8.19	8.57	8.95	9.32	9.70	10.07	10.45	10.83

SP3 General road improvements, continued

Accident cost savings **Worksheet 6**

	Movement category		Vehicle involvement	
1	Do minimum mean speed		Road category	
	Posted speed limit		Traffic growth rate	
2	Option mean speed			

	Do minimum	**Severity**			**Non-injury**
		Fatal	**Serious**	**Minor**	
3	Number of years of typical accident rate records				
4	Number of reported accidents over period				
5	Fatal/serious severity ratio (tables A6.19(a) to (c))			1.0	1.0
6	Number of reported accidents adjusted by severity **(4)** × **(5)**				
7	Accidents per year = **(6)**/**(3)**				
8	Adjustment factor for accident trend (table A6.1(a))				
9	Adjusted accidents per year = **(7)** x **(8)**				
10	Under-reporting factors (tables A6.20(a) and (b))				
11	Total estimated accidents per year = **(9)** x **(10)**				
12	Accident cost, 100 km/h limit (tables A6.21(e) to (h))				
13	Accident cost, 50 km/h limit (tables A6.21(a) to (d))				
14	Mean speed adjustment = (**(1)** - 50)/50				
15	Cost per accident = **(13)** + **(14)** x [**(12)** – **(13)**]				
16	Accident cost per year = **(11)** x **(15)**				
17	Total cost of accidents per year (sum of columns in row **(16)** fatal + serious + minor + non-injury) $				
	Option				
18	Percentage accident reduction				
19	Percentage of accidents 'remaining' [100 – **(18)**]				
20	Predicted accidents per year **(11)** x **(19)**				
21	Accident cost, 100km/h speed limit (tables A6.21(e) to (h))				
22	Accident cost, 50km/h speed limit (tables A6.21(a) to (d))				
23	Mean speed adjustment = (**(2)** - 50)/50				
24	Cost per accident = **(22)** + **(23)** x [**(21)** – **(22)**]				
25	Accident cost per year = **(20)** x **(24)**				
26	Total cost of accidents per year (sum of columns in row **(25)** fatal + serious + minor + non-injury) $				
27	Annual accident cost savings = **(17)** – **(26)** $				
28	PV accident cost savings = **(27)** x DF^{AC} $				**E**

Transfer PV of accident cost savings, **E** for the preferred option to **E** on worksheet 1

SP3 General road improvements, continued

Explanation for worksheet 7 **BCR and incremental analysis**

Cost benefit analysis

1. Under benefits, enter the PVs for the benefits for the do minimum and for each option. Then subtract the benefits for the options from the benefits for the do minimum to get the net benefits for each option.
2. Under costs, enter the PVs for the capital, maintenance and operating costs for the do minimum and each option. Subtract the PV costs for the do minimum from the costs for each of the options to get the net costs of each option.
3. Calculate the BCR by dividing the net benefits by the net costs.

Incremental analysis

1. Select the appropriate target incremental BCR from appendix A12.4.
2. Rank the options in order of increasing cost.
3. Compare the lowest cost option with the next higher cost option to calculate the incremental BCR.
4. If the incremental BCR is less than the target incremental BCR, discard the second option in favour of the first and compare the first option with the next higher cost option.
5. If the incremental BCR is greater than the target incremental BCR, the second option becomes the basis for comparison against the next higher cost option.
6. Repeat the procedure until no higher cost options are available that have an incremental BCR greater than the target incremental BCR. The highest cost option with an incremental BCR greater than the target incremental BCR is generally the preferred option.

SP3 General road improvements, continued

BCR and incremental analysis **Worksheet 7**

Time zero _____

Base date _____

BCR_N	Do minimum	Option A	Option B	Option C	Option A	Option B	Option C
	PV of benefits as calculated				**PV of net benefits**		
Travel time cost savings							
VOC and CO_2 savings							
Accident cost savings							
PV total net benefits							
	PV of costs as calculated				**PV of net costs**		
Capital costs							
Maintenance costs							
PV total net costs							
BCR_N							

Target incremental BCR (from appendix A12.4) _____

Base option for comparison			**Next higher cost option**			**Incremental analysis**		
Option	**Total costs (1)**	**Total benefits (2)**	**Option**	**Total costs (3)**	**Total benefits (4)**	**Incremental costs (5)=(3)-(1)**	**Incremental benefits (6)=(4)-(2)**	**Incremental BCR_N (7)=(6)/(5)**

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SP4 Seal extensions

Introduction

These procedures (SP3) provide a simplified method of appraising the economic benefits and costs of proposed seal extension works. The method may be subject to capital cost limits specified in section 4.2. There are no capital limits set.

The procedures are designed to consider one option at a time. All suitable options for the proposed works should be considered in order to select the optimal solution. In most situations this will involve incremental analysis of the benefits and costs of the different options analysed. A description of all options considered should be provided in worksheet 1 and included in the incremental analysis; for all other worksheets, only the details for the preferred option needs to be included.

To use the worksheets it is necessary to determine the traffic growth rate for the project. This can be done either by analysing the traffic count data (for at least the last 5 years and preferably for the last 10 years) or by using the default values in appendix A2.5.

The worksheets use a 10% discount rate and a 25 year evaluation period. The procedure assumes that funded projects will be completed in the first year and will be in service by the start of year 2. Where costs are common to both the do minimum and the option under consideration, they are not included in the analysis. All costs are to be exclusive of GST.

Worksheet	Description
1	Evaluation summary
2	Cost of the do minimum
3	Cost of the option
4	Travel time cost savings and seal extension benefits
5	Vehicle operating cost savings
6	Accident cost savings
7	BCR and incremental analysis sheet

SP4 Seal extensions, continued

Explanation for worksheet 1 **Evaluation summary**

Worksheet 1 provides a summary of the general data used for the evaluation as well as the results of the analysis.

The information required is a subset of the information entered into LTP online.

1. Evaluator(s)/reviewer(s): Enter the full name, contact details, name of organisation, office location, etc, of the evaluator(s) and reviewer(s).
2. Project/package details: Provide a general description of the project and package (where relevant),. describe the problems with the existing road section.
3. Location: A brief description of the project location including:
   - a location/route map
   - a layout plan of the project.
4. Alternatives and options: Describe the do minimum. This is to maintain the road in an unimproved state. Describe the options assessed and how the preferred option will improve the road section.
5. Timing: For purposes of economic evaluation the construction start is assumed to be 1 July of the financial year in which the project is submitted for a commitment to funding.
6. Economic efficiency: Enter the timeframe information, the road and traffic data, identify the existing and predicted traffic speed, the existing and predicted roughness (IRI or NAASRA), the length and width of road before and after works.
7. PV cost of do minimum: Use worksheet 2 to calculate the PV cost of the do minimum. This should be the lowest cost option that will keep the road in service. It will provide no improvements.
8. PV cost of the preferred option: Use worksheet 3 to estimate the preferred option PV cost.
9. Enter the benefits values from worksheets 4 (travel time cost savings and seal extension benefits), 5 (vehicle operating cost savings) and 6 (accident cost savings). To bring the benefits up to the base date values, use the appropriate update factors supplied in appendix A12.3. The base VOC incorporates the CO_2 costs and no separate adjustment is required.
10. The national benefit cost ratio is calculated by dividing the PV of the net benefits (PV benefits of the do minimum subtracted from the PV benefits of the option) by PV of the net costs (PV costs of the do minimum subtracted from the PV costs of the option).
11. First year rate of return is calculated as the benefits in the first full year following completion divided by the project costs. The first year benefits are calculated by dividing the totals at **W**, **Y** and **Z** by the discount factors used on worksheets 4, 5 and 6 respectively then multiplying by 0.91 to get the present value.

Note: the discount factor for accident cost savings (see explanation for worksheet 6) is different to the discount factor for the other benefits (see explanation for worksheets 4 and 5).

SP4 Seal extensions, 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 problem to be addressed _____

3 **Location** _____

Brief description of location _____

_____

4 **Alternatives and options**

Describe the do minimum _____

_____

Summarise the options assessed _____

_____

5 **Timing**

Time zero (assumed construction start date) 1 July

Expected duration of construction (months) _____

6 **Economic efficiency**

Date economic evaluation completed (mm/yyyy) _____

Base date for costs and benefits 1 July

AADT at time zero _____

Traffic growth rate at time zero (%) _____

Existing roughness count	_____	IRI or NAASRA	Existing traffic speed	_____	km/h
Predicted roughness count	_____	IRI or NAASRA	Predicted traffic speed	_____	km/h
Length of road before works	_____	km	Width of road before works	_____	m
Length of road after works	_____	km	Width of road after works	_____	m

7 **PV cost of do minimum** $ _____ **A**

8 **PV cost of the preferred option** $ _____ **B**

9 **Benefit values from worksheet 4, 5 and 6**

PV travel time cost savings	$ _____	**C** x Update factor ^{TTC}	_____	= $	_____	**W**
PV seal extension benefits	$ _____	**K** x Update factor ^{TTC}	_____	= $	_____	**X**
PV VOC and CO_2 savings	$ _____	**D** x Update factor ^{VOC}	_____	= $	_____	**Y**
PV accident cost savings	$ _____	**E** x Update factor ^{AC}	_____	= $	_____	**Z**

10 $BCR_N = \frac{\text{PV net benefits}}{\text{PV net costs}} = \frac{\mathbf{W} + \mathbf{X} + \mathbf{Y} + \mathbf{Z}}{\mathbf{B} - \mathbf{A}} =$ _____ =

11 $FYRR = \frac{\text{PV 1st year benefits}}{\text{PV net costs}} = \frac{[(\mathbf{W} + \mathbf{X} + \mathbf{Y}) / DF^{VOC} + (\mathbf{Z} / DF^{AC})] \times 0.91}{\mathbf{B} - \mathbf{A}} =$ _____ %

SP4 Seal extensions, continued

Explanation for worksheet 2 **Costs of do minimum**

Worksheet 2 is used to calculate the PV cost of the do minimum. The do minimum is the minimum level of expenditure necessary to keep a road open and the costs are generally maintenance grading and maintenance metal.

1. Enter the length of the work in km and the number of gradings per year.
2. Enter the cost of grading per km and calculate the annual cost of maintenance grading **(a)**.
3. Estimate the quantity in m^3 and the cost/m^3 for metal dressing and calculate the annual costs **(b)**.
4. Add **(a)** and **(b)** together, then multiply by 9.52 to calculate the PV of the do minimum maintenance costs **(c)**.
5. Schedule any periodic heavy maintenance, according to the year in which this work is expected to be undertaken. Apply the appropriate single payment present worth factor (SPPWF from table 1) and determine the present value at time zero. Sum the PV of the periodic costs to determine the PV of total periodic maintenance costs **(d)**.
6. Calculate the PV total costs of the do minimum by adding **(c)** + **(d)**. Transfer the total to **A** on worksheet 1.

Table 1 Single payment present worth factors (for 10% discount rate)

Year	SPPWF	Year	SPPWF
1	0.91	14	0.26
2	0.83	15	0.24
3	0.75	16	0.22
4	0.68	17	0.20
5	0.62	18	0.18
6	0.56	19	0.16
7	0.51	20	0.15
8	0.47	21	0.14
9	0.42	22	0.12
10	0.39	23	0.11
11	0.35	24	0.10
12	0.32	25	0.09
13	0.29		

SP4 Seal extensions, continued

Costs of do minimum **Worksheet 2**

1 Section maintenance data

Section length **L** _____ km

No of gradings per year **G** _____

2 Maintenance grading costs per year

Length **L** _____ x gradings **G** _____ x rate/km _____ = $ _____ /yr **(a)**

3 Maintenance metal costs per year

Quantity _____ m³ x rate _____ = $ _____ /yr **(b)**

4 PV of annual maintenance costs (years 1 to 25)

[**(a)** + **(b)**] × 9.52 = $ _____ **(c)**

5 PV of periodic maintenance costs

Periodic maintenance will be required in the following years:

Year	Type of maintenance	Amount $	SPPWF	Present value

Sum of PV of periodic maintenance costs $ _____ **(d)**

6 PV of total costs of do minimum

(c) + (d) = $ _____ **A**

Transfer total to **A** on worksheet 1

SP4 Seal extensions, continued

Explanation for worksheet 3 **Costs of the option(s)**

Worksheet 3 is used for calculating the PV cost of the seal extension works. Indicate if the option is with or without improvements and describe improvements (if any). These may be need to be evaluated separately using SP3 for road improvements.

1. Enter the capital cost (including professional services for design and supervision) of the proposed option. The cost is estimated separately on an estimate sheet, which should be attached to this worksheet. Multiply the cost by the discount factor 0.91 and enter at **(a)**.
2. Enter the cost of maintenance for year 1 at **(b)**. As this is assumed to be the year that the proposed option works are carried out, this cost will commonly be the same as that for the existing maintenance strategy, as per step 2 on worksheet 2.
3. Enter the cost for annual maintenance and inspections following completion of the works. Multiply by 8.57 to get the PV of annual maintenance costs **(c)** for years 2 to 25 inclusive.
4. Enter the costs of periodic maintenance (including second coat seal; heavy maintenance prior to resealing; and the cost future of reseals as appropriate). Determine which years this maintenance will be required (if at all) and enter the year, estimated cost and SPPWF (from the table 1 in worksheet 2). Calculate the present value (estimated cost × SPPWF) for each type of cost and sum these to obtain the PV of the total periodic maintenance cost **(d)**.
5. The sum of **(a)** + **(b)** + **(c)** + **(d)** gives the PV total cost of the option, **B**. Transfer PV total costs of the preferred option to **B** on worksheet 1.

SP4 Seal extensions, continued

Costs of the option(s) **Worksheet 3**

1 PV of estimated cost of proposed work (as per attached estimate sheets)

$ _____ × 0.91 = $ _____ **(a)**

2 PV of maintenance cost in year 1 = $ _____ **(b)**

3 PV of annual maintenance costs following completion of the work

(years 2 to 25 inclusive) $ _____ × 8.57 = $ _____ **(c)**

4 PV of periodic maintenance costs

Year	Type of maintenance	Amount $	SPPWF	Present value
			Sum of PV of periodic maintenance costs = $	**(d)**

5 PV of total costs of option

PV total costs (a) + (b) + (c) + (d) = $ _____ **B**

Transfer PV total costs of the preferred option to **B** on worksheet 1

SP4 Seal extensions, continued

Explanation for worksheet 4 Travel time cost savings and seal extension benefits

Worksheet 4 is used for calculating the travel time cost savings and the benefits for seal extensions.

1. Circle the road type.
2. Enter the data required to complete the travel time savings and comfort benefits calculations. The increase in mean vehicle speeds and travel time costs for the do minimum and options can be obtained from the tables 1 and 2 below.
3. Calculate the annual travel time costs for the do minimum **(a)** using the formula provided.
4. Calculate the annual travel time costs for the option **(b)** using the formula provided.
5. Calculate the annual travel time cost savings by subtracting the travel time costs for the option **(b)** from the do minimum travel time costs **(a)** to get **(c)**.
6. Determine the PV of the travel time cost savings, multiplying **(c)** by the appropriate discount factor from table 3 below. Transfer the PV of travel time cost savings, **C** to worksheet 1.
7. Seal extension benefits: the standard value for comfort benefits associated with sealing unsealed roads is 10¢/vehicle/km. Productivity gains are: $50/km/year for beef and sheep farms; $150/km/year for dairy farms; $300/km/year for horticulture land. The length (in km) of the do minimum unsealed road that is sealed is used to obtain the annual comfort benefit **(d)** and the annual productivity benefit **(e)**.
8. Determine the PV of the seal extension benefits, multiplying **(d)** + **(e)** by the appropriate discount factor from table 3 below. Transfer the PV of seal extension benefits, **K** to worksheet 1.

Table 1 Increase in mean speed for seal extension works

Unsealed section mean speed of light vehicles	Sealed section increase in mean speed (km/h) for increase in carriageway width (m)		
	No increase (seal as is)	Increase of 1 metre	Increase of 2 metres
> 60 km/h	0	5	10
45 to 60 km/h	5	10	20
35 to 45 km/h	10	15	25
< 35 km/h	15	20	30

Table 2 Travel time cost for standard traffic mixes for all periods combined (July 2002)

Road type	Description	Travel time cost ($/hr)
Urban other	Urban roads carrying traffic of 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/day	23.25
Rural other	Rural roads other than rural strategic	22.72

Table 3 Travel time cost and seal extension benefit discount factors (DF^{TTC}) for different traffic growth rates for years 2 to 25 inclusive

Traffic growth rate	0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
Discount factor (DF^{TTC})	8.57	8.95	9.32	9.70	10.07	10.45	10.83	11.20	11.58

SP4 Seal extensions, continued

Travel time cost savings and seal extension benefits **Worksheet 4**

1 Road type (circle) urban other/rural strategic/rural other

2 Base data

AADT (or the traffic volumes affected by the improvement) _____

Traffic growth rate (per annum) _____

Travel time cost, TTC $ _____

	Do minimum		Option	
Length of route in km	L^{dm}		L^{opt}	
Mean vehicle speed	VS^{dm}		VS^{opt}	

3 Annual travel time costs for the do minimum

$$\frac{AADT \times 365 \times L^{dm} \times TTC}{VS^{dm}} = \$ \_\_\_\_\_ \textbf{(a)}$$

4 Annual travel time costs for the option

$$\frac{AADT \times 365 \times L^{opt} \times TTC}{VS^{opt}} = \$ \_\_\_\_\_ \textbf{(b)}$$

5 Value of annual travel time cost savings **(a) – (b)** = $ _____ **(c)**

6 PV of travel time cost savings **(c)** x DF^{TTC} = $ _____ **C**

Transfer PV of travel time cost savings, **C** for the preferred option to **C** on worksheet 1

7 Value of annual seal extension benefits

Annual comfort benefit $AADT \times 365 \times L^{dm} \times 0.10$ = $ _____ **(d)**

Annual productivity gain $L^{dm} \times$ _____ = $ _____ **(e)**

8 PV of seal extension benefits **[(d) + (e)]** x DF^{TTC} = $ _____ **K**

Transfer PV of seal extension benefits, **K** for the preferred option to **K** on worksheet 1

SP4 Seal extensions, continued

Explanation for worksheet 5 **Vehicle operating cost savings**

Worksheet 5 is used for calculating vehicle operating cost (VOC) savings.

1. Enter the base data required for analysis of VOC savings. Table 1 provides the base VOCs (CB) in cents/km for different gradients and mean vehicle speeds, while table 2 provides roughness costs (CR) in cents/km for different road roughness.
2. Calculate the annual VOCs **(a)** for the do minimum using the formula provided.
3. Calculate the annual VOCs **(b)** for the option using the formula provided.
4. Calculate the annual VOC savings by subtracting the VOCs for the option **(b)** from the do minimum VOCs (a) to get **(c)**.
5. Determine the PV of the VOC savings, **D** by multiplying **(c)** by the appropriate discount factor from table 3. Transfer the PV of VOC savings, **D** for the preferred option to worksheet 1.

Table 1 Base vehicle operating costs (CB) including CO_2 - in cents/km (July 2002)

% gradient	**Mean vehicle speed** (over length of route)				
	0–30 km/h	**31-50 km/h**	**51-70 km/h**	**71-90 km/h**	**91-105 km/h**
0	24.1	20.1	19.7	20.3	21.3
1 to 3	24.4	20.4	19.9	20.6	21.6
4 to 6	25.3	21.5	21.0	21.7	22.7
7 to 9	26.7	23.2	22.9	23.6	24.7
10 to 12	28.5	25.3	25.2	26.2	27.4

Table 2 Roughness costs (CR) in cents/km (July 2002)

Unsealed road roughness before sealing can be assumed to be 6.5 IRI (≈170 NAASRA counts) and 2.5 IRI (≈66 NAASRA counts) after sealing. If values higher than 6.5 IRI (or 170 NAASRA) for initial roughness of unsealed roads are used these need to be substantiated.

IRI m/km	NAASRA counts/ km	CR cents/km urban	CR cents/km rural	IRI m/km	NAASRA counts/ km	CR cents/km urban	CR cents/km rural
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

Table 3 VOC discount factors (DF^{VOC}) for different traffic growth rates for years 2 to 25 inclusive

Growth rate	0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
Discount factor (DF^{VOC})	8.57	8.95	9.32	9.70	10.07	10.45	10.83	11.20	11.58

SP4 Seal extensions, continued

Vehicle operating cost savings **Worksheet 5**

1 Base data

Traffic growth rate (per annum) _____ %

AADT (or the traffic volumes affected by the improvement) _____

	Do minimum		Option	
Length of route in km	L^{dm}		L^{opt}	
Roughness (IRI/NAASRA)				
Roughness cost	CR^{dm}		CR^{opt}	
Mean vehicle speed	VS^{dm}		VS^{opt}	
Gradient				
Base cost	CB^{dm}		CB^{opt}	

2 Annual vehicle operating cost for the do minimum

$$\frac{L^{dm} \times (CR^{dm} + CB^{dm}) \times AADT \times 365}{100} = \$ \_\_\_\_\_ \textbf{(a)}$$

3 Annual vehicle operating cost for the option

$$\frac{L^{opt} \times (CR^{opt} + CB^{opt}) \times AADT \times 365}{100} = \$ \_\_\_\_\_ \textbf{(b)}$$

4 Value of annual vehicle operating cost savings **(a) – (b)** = $ _____ **(c)**

5 PV of vehicle operating cost savings **(c)** x DF^{VOC} = $ _____ **D**

Transfer PV of vehicle operating cost savings, **D** for the preferred option to **D** on worksheet 1

SP4 Seal extensions, continued

Explanation for worksheet 6 **Accident cost savings**

These simplified procedures are 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 worksheet 1 as total **E**.

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)**.
9. 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)**.
10. 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)**.
11. 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)**.
12. 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)**.
13. Calculate the annual accident cost savings by subtracting the values in **(26)** from **(17)**. Multiply the annual accident cost savings **(27)** – or the total from the accident rate or weighted accident analysis – by the discount factor in table 1 for the appropriate speed limit and traffic growth rate to determine the PV accident cost savings. Transfer this total, **E** for the preferred option to worksheet 1.

Table 1 Accident cost discount factor (DF^{AC}) for different traffic growth rates and speed limits for years 2 to 25 inclusive

Traffic growth rate	0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
50 and 60 km/h	6.31	6.69	7.07	7.44	7.82	8.19	8.57	8.95	9.32
≥ 70 km/h	7.82	8.19	8.57	8.95	9.32	9.70	10.07	10.45	10.83

SP4 Seal extensions, continued

Accident cost savings **Worksheet 6**

	Movement category		Vehicle involvement	
1	Do minimum mean speed		Road category	
	Posted speed limit		Traffic growth rate	
2	Option mean speed			

	Do minimum	**Severity**			**Non-injury**
		Fatal	**Serious**	**Minor**	
3	Number of years of typical accident rate records				
4	Number of reported accidents over period				
5	Fatal/serious severity ratio (tables A6.19(a) to (c))			1	1
6	Number of reported accidents adjusted by severity **(4)** × **(5)**				
7	Accidents per year = **(6)**/**(3)**				
8	Adjustment factor for accident trend (table A6.1(a))				
9	Adjusted accidents per year = **(7)** x **(8)**				
10	Under-reporting factors (tables A6.20(a) and (b))				
11	Total estimated accidents per year = **(9)** x **(10)**				
12	Accident cost, 100 km/h limit (tables A6.21(e) to (h))				
13	Accident cost, 50 km/h limit (tables A6.21(a) to (d))				
14	Mean speed adjustment = (**(1)** - 50)/50				
15	Cost per accident = **(13)** + **(14)** x [**(12)** – **(13)**]				
16	Accident cost per year = **(11)** x **(15)**				
17	Total cost of accidents per year (sum of columns in row **(16)** fatal + serious + minor + non-injury) $				
	Option				
18	Percentage accident reduction				
19	Percentage of accidents 'remaining' [100 – **(18)**]				
20	Predicted accidents per year **(11)** x **(19)**				
21	Accident cost, 100km/h speed limit (tables A6.21(e) to (h))				
22	Accident cost, 50km/h speed limit (tables A6.21(a) to (d))				
23	Mean speed adjustment = (**(2)** - 50)/50				
24	Cost per accident = **(22)** + **(23)** x [**(21)** – **(22)**]				
25	Accident cost per year = **(20)** x **(24)**				
26	Total cost of accidents per year (sum of columns in row **(25)** fatal + serious + minor + non-injury) $				
27	Annual accident cost savings = **(17)** – **(26)** $				
28	PV accident cost savings = **(27)** x DF^{AC} $				**E**

Transfer PV of accident cost savings, **E** for the preferred option to **E** on worksheet 1

SP4 Seal extensions, continued

Explanation for worksheet 7 **BCR and incremental analysis**

Cost benefit analysis

1. Under benefits, enter the PVs for the benefits for the do minimum and for each option. Then subtract the benefits for the options from the benefits for the do minimum to get the net benefits for each option.
2. Under costs, enter the PVs for the capital, maintenance and operating costs for the do minimum and each option. Subtract the PV costs for the do minimum from the costs for each of the options to get the net costs of each option.
3. Calculate the national BCR by dividing the net benefits by the net costs.

Incremental analysis

1. Select the appropriate target incremental BCR from appendix A12.4.
2. Rank the options in order of increasing cost.
3. Compare the lowest cost option with the next higher cost option to calculate the incremental BCR.
4. If the incremental BCR is less than the target incremental BCR, discard the second option in favour of the first and compare the first option with the next higher cost option.
5. If the incremental BCR is greater than the target incremental BCR, the second option becomes the basis for comparison against the next higher cost option.
6. Repeat the procedure until no higher cost options are available that have an incremental BCR greater than the target incremental BCR. The highest cost option with an incremental BCR greater than the target incremental BCR is generally the preferred option.

SP4 Seal extensions, continued

BCR and incremental analysis **Worksheet 7**

Time zero _____

Base date _____

BCR_N	Do minimum	Option A	Option B	Option C	Option A	Option B	Option C
	PV of benefits as calculated				**PV of net benefits**		
Travel time cost savings and seal extension benefits							
VOC and CO_2 savings							
Accident cost savings							
PV total net benefits							
	PV of costs as calculated				**PV of net costs**		
Capital costs							
Maintenance costs							
PV total net costs							
BCR_N							

Target incremental BCR (from appendix A12.4) _____

Base option for comparison			Next higher cost option			Incremental analysis		
Option	**Total costs (1)**	**Total benefits (2)**	**Option**	**Total costs (3)**	**Total benefits (4)**	**Incremental costs (5)=(3)-(1)**	**Incremental benefits (6)=(4)-(2)**	**Incremental BCR_N (7)=(6)/(5)**

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SP5 Isolated intersection improvements

Introduction

These procedures (SP5) provide a method of evaluating the economic efficiency of isolated intersection improvements and are intended for projects that have an undiscounted capital cost up to the limits specified in section 4.2.

Accident analysis involving an isolated intersection is only to be undertaken where the site has an accident history of:

- four or more non-injury accidents
- one injury and three or more non-injury accidents, or
- two or more injury accidents.

The most recent 5 calendar year accident history for the site should be used. Detailed accident listings, collision diagrams, a description of common factors in the accidents and a diagnosis of the site factors contributing to the problem should be submitted with the evaluation.

The procedures are designed to consider one option at a time. All suitable options for the proposed works should be considered in order to select the optimal solution. In most situations this will involve incremental analysis of the benefits and costs of the different options. A description of all options considered should be provided in worksheet 1 and included in the incremental analysis; for all other worksheets, only the details for the preferred option needs to be included.

It is necessary to determine the traffic growth rate for the project. This can be done by analysing traffic count data (for at least the last 5 years and preferably for the last 10 years) or by using default values in appendix A2.5.

The worksheets use a 10% discount rate and a 25 year evaluation period. The procedure assumes that funded projects will be completed in the first year and will be in service by the start of year 2. Where costs are common to both the do minimum and the option under consideration, they are not included in the analysis. All costs are to be exclusive of GST.

Worksheet	Description
1	Evaluation summary
2	Cost of the do minimum
3	Cost of the option
4	Travel time cost savings
5	Vehicle operating cost savings
6	Accident cost savings
7	BCR and incremental analysis sheet

SP5 Isolated intersection improvements, continued

Explanation for worksheet 1 **Evaluation summary**

Worksheet 1 provides a summary of the general data used for the evaluation and the analysis results. The information required is a subset of the information entered into LTP online.

1. Evaluator(s)/reviewer(s): Enter the full name, contact details, name of organisation, office location, etc, of the evaluator(s) and reviewer(s).
2. Project/package details: Provide a general description of the project and package (where relevant). Describe the problems with the existing intersection.
3. Location: A brief description of the project location including:
   - a location/route map
   - a layout plan of the project.
4. Alternatives and options: Describe the do minimum, which is usually the least cost option to maintain the intersection in an unimproved state. Describe the options assessed and how the preferred option will improve the intersection.
5. Timing: For purposes of the economic efficiency evaluation, the construction start is assumed to be 1 July of the financial year in which the project is submitted for a commitment to funding.
6. Economic efficiency: Enter the timeframe information, road and traffic data, posted speed limit and traffic volume entering the intersection.
7. PV cost of do minimum: Use worksheet 2 to calculate the PV cost of the do minimum. This should be the lowest cost option that will keep the road in service. It will provide no improvements.
8. PV cost of the preferred option: Use worksheet 3 to estimate the preferred option PV cost.
9. Enter the benefits values from worksheets 4 (travel time cost savings), 5 (vehicle operating cost savings) and 6 (accident cost savings). To bring the benefits up to the base date values, use the appropriate update factors supplied in appendix A12.3. The base VOC incorporates the CO_2 costs and no separate adjustment is required.
10. The national benefit cost ratio is calculated by dividing the PV of the net benefits (PV benefits of the do minimum subtracted from the PV benefits of the option) by PV of the net costs (PV costs of the do minimum subtracted from the PV costs of the option).
11. First year rate of return is calculated as the benefits in the first full year following completion divided by the project costs. The first year benefits are calculated by dividing the totals at **W**, **Y** and **Z** by the discount factors for travel time cost, VOC and accidents respectively. Then multiplying by 0.91 to get the present value.
12. Note: the discount factor for accidents (see explanation for worksheet 6) is different to the discount factor for VOC and travel time cost (see explanation for worksheets 4 and 5).

Table 1 Travel time cost and VOC discount factors (DF^{TTC} and DF^{VOC}) for different traffic growth rates for years 2 to 25 inclusive

Traffic growth rate	0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
Discount factor	8.57	8.95	9.32	9.70	10.07	10.45	10.83	11.20	11.58

SP5 Isolated intersection improvements, 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 problem to be addressed _____

_____

3 **Location**

Brief description of location _____

_____

4 **Alternatives and options**

Describe the do minimum _____

_____

Summarise the options assessed _____

_____

5 **Timing**

Time zero (assumed construction start date) 1 July

Expected duration of construction (months) _____

6 **Economic efficiency**

Date economic evaluation completed (mm/yyyy) _____

Base date for costs and benefits 1 July

AADT at time zero _____

Traffic growth rate at time zero (%) _____

Traffic volume entering the intersection _____ in the year _____

Posted speed limit _____ km/h

7 **PV cost of do minimum** $ _____ **A**

8 **PV cost of the preferred option** $ _____ **B**

9 **Benefit values from worksheet 4, 5 and 6**

PV travel time cost savings $ _____ **C** x Update factor ^{TTC} _____ = $ _____ **W**

PV VOC and CO_2 savings $ _____ **D** x Update factor ^{VOC} _____ = $ _____ **Y**

PV accident cost savings $ _____ **E** x Update factor ^{AC} _____ = $ _____ **Z**

10 $BCR_N = \frac{\text{PV net benefits}}{\text{PV net costs}} = \frac{\mathbf{W} + \mathbf{Y} + \mathbf{Z}}{\mathbf{B} - \mathbf{A}} = \_\_\_\_\_ =$ _____

11 $FYRR = \frac{\text{PV 1st year benefits}}{\text{PV net costs}} = \frac{[(\mathbf{W} + \mathbf{Y}) / DF^{VOC} + (\mathbf{Z} / DF^{AC})] \times 0.91}{\mathbf{B} - \mathbf{A}} =$ _____ %

SP5 Isolated intersection improvements, continued

Explanation for worksheet 2 **Costs of do minimum**

Worksheet 2 is used to calculate the PV cost of the do minimum. The do minimum is the minimum level of expenditure necessary to keep an intersection open and generally consists of maintenance work.

In a limited number of cases, the do minimum will involve capital expenditure. The cost of any works (including investigation, design and construction) must be included in the evaluation. The costs should be discounted to present value by multiplying by the SPPWF for year 1 (0.91) and reported as one of the periodic maintenance costs.

1. Enter the historic maintenance cost data. The annual and periodic maintenance costs should be obtained from maintenance records and resealing records.
2. Calculate the PV of annual maintenance costs **(a)** for the do minimum by multiplying the annual cost by the discount factor of 9.52.
3. Schedule any periodic maintenance, according to the year in which this work is expected to be undertaken. Apply the appropriate single payment present worth factor (SPPWF) from table 1 below to determine the PV at time zero. Sum the PV of the periodic costs to determine the PV of total periodic maintenance costs **(b)**.
4. Calculate the PV of the annual costs associated with operating the intersection **(c)** for the do minimum by multiplying the annual cost by the discount factor of 9.52. Note: operating costs must be distinct from, and in addition to, maintenance costs.
5. Calculate the PV total costs of the do minimum by adding **(a)** + **(b)** + **(c)**. Transfer the total to **A** on worksheet 1.

Table 1 Single payment present worth factors (for 10% discount rate)

Year	SPPWF	Year	SPPWF
1	0.91	14	0.26
2	0.83	15	0.24
3	0.75	16	0.22
4	0.68	17	0.20
5	0.62	18	0.18
6	0.56	19	0.16
7	0.51	20	0.15
8	0.47	21	0.14
9	0.42	22	0.12
10	0.39	23	0.11
11	0.35	24	0.10
12	0.32	25	0.09
13	0.29		

SP5 Isolated intersection improvements, continued

Cost of do minimum **Worksheet 2**

1 Historic maintenance cost data (indicate whether assessed or actual)

Maintenance costs for the site over the last 3 years

Year 1 $ _____

Year 2 $ _____

Year 3 $ _____

Maintenance costs for the site this year $ _____

Assessed future maintenance costs $ _____

2 PV of annual maintenance costs

Total = $ _____ × 9.52 = $ _____ **(a)**

3 PV of periodic maintenance costs (include any capital works)

Periodic maintenance will be required in the following years:

Year	Type of maintenance	Amount $	SPPWF	Present value

Sum of PV of periodic maintenance costs $ _____ **(b)**

4 PV of annual operating costs

Total = $ _____ × 9.52 = $ _____ **(c)**

5 PV of total do minimum costs

(a) + (b) + (c) = $ _____ **A**

Transfer total to **A** on worksheet 1

SP5 Isolated intersection improvements, continued

Explanation for worksheet 3 **Costs of the option**

Worksheet 3 is used for calculating the PV cost of the isolated intersection improvements.

1. Enter the capital cost (including professional services for design and supervision) of the proposed option. The cost is estimated separately on an estimate sheet, which should be attached to this worksheet. Where construction items have an estimated life of less than 25 years, the cost of the item should be multiplied by the factor (MF) given in table 1 below to obtain the total cost for that item over 25 years. Add the cost of the works together, including the adjusted capital items costs. Multiply the cost by the discount factor 0.91 and enter at **(a)**.
2. Enter the cost of maintenance for year 1 at **(b)**. As this is assumed to be the year that the proposed option works are carried out, this cost will commonly be the same as that for the existing maintenance strategy, as per step 2 on worksheet 2.
3. Enter the cost for annual maintenance following completion of the works. Where periodic renewal of capital items (including traffic signs, delineation, spray plastic and road markings) have been included in the cost of works at **(a)**, these should be excluded from the maintenance cost stream. Multiply the annual maintenance costs by 8.57 to get the PV of annual maintenance costs **(c)** for years 2 to 25 inclusive.
4. Enter the costs of periodic maintenance. Determine which years this maintenance will be required (if at all) and enter the year, estimated cost and SPPWF (from the table in worksheet 3). Calculate the present value (estimated cost × SPPWF) for each type of cost and sum these to obtain the PV of the total periodic maintenance cost **(d)**.
5. Calculate the PV of the annual costs associated with operating the intersection **(e)** for the option by multiplying the annual cost by the discount factor of 8.57. Note: operating costs must be distinct from, and in addition to, maintenance costs.
6. The sum of **(a)** + **(b)** + **(c)** + **(d)** + **(e)** gives the PV total cost of the option, **B**. Transfer **B** for the preferred option to worksheet 1.

Table 1 Multiplication factors for items with an estimated life of less than 25 years

Construction item	Multiplying factor (MF)
Traffic signs	1.7
Delineation (eg edge market posts, raised pavement markers, sight railing and chevrons)	2.2
Spray plastic	4.0
Road markings	11.1

SP5 Isolated intersection improvements, continued

Costs of the option **Worksheet 3**

1 PV of estimated cost of proposed work (as per attached estimate sheets)

$ _____ × 0.91 = $ _____ **(a)**

2 PV of maintenance cost in year 1 = $ _____ **(b)**

3 PV of annual maintenance costs following completion of the work

(years 2 to 25 inclusive) $ _____ × 8.57 = $ _____ **(c)**

4 PV of periodic maintenance costs

Year	Type of maintenance	Amount $	SPPWF	Present value
			Sum of PV of periodic maintenance costs = $	**(d)**

5 PV of annual operating costs (separate to maintenance costs)

(years 2 to 25 inclusive) $ _____ × 8.57 = $ _____ **(e)**

6 PV total costs of option

PV total costs (a) + (b) + (c) + (d) + (e) = $ _____ **B**

Transfer PV total costs of the preferred option to **B** on worksheet 1

SP5 Isolated intersection improvements, continued

Explanation for worksheet 4 **Travel time cost savings**

This worksheet is used for calculating travel time cost savings from modifying or changing the control of an intersection eg, from priority control to traffic signals. Intersection analysis requires modelling to be used for both the do minimum and project option. It is not allowable to compare calculated delay and measured delay. Instead, the measured delay must be used to calibrate the calculated delay.

The annual travel time costs for the do minimum and the project option are to be calculated either using direct output from a suitable computer programme or by aggregating outputs for representative time periods. Output and notes should be attached. Alternatively, fill in the tables in worksheet 4 as per the instructions below.

Default travel time costs (TTC) are in the table 1 below for the standard road types.

Table 1 Travel time cost for standard traffic mixes for all periods combined (July 2002)

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

The travel time cost (TTC) calculations start at the beginning of year 2 (following completion of construction works in year 1) and finish at the end of year 25.

For each six year time period:

1. Enter the value of the TTC at the mid-point for the do minimum **(1)**. For example, in the first six year period (years 2 – 7), the end of year 4 is the mid-point; in years 20 – 25, the mid-point is the end of year 22.
2. Enter the value of the TTC at the mid-point for the project option **(2)**.
3. Calculate the 'mid-point benefits' **(3)** by subtracting the option TTC **(2)** from the do minimum TTC **(1)** from to obtain $\mathbf{c^1}$, $\mathbf{c^2}$, $\mathbf{c^3}$, and $\mathbf{c^4}$.
4. Using the formula provided, calculate the PV of the travel time cost savings for the project option **C**. In the formula, each mid-point benefit value is multiplied by 6 to obtain the 6 yearly total, which is then discounted to get the PV for each 6 year interval. The results for each 6 year period are summed to obtain the PV total travel time savings, **C**. Transfer **C** for the preferred option to worksheet 1.

SP5 Isolated intersection improvements, continued

Travel time cost savings **Worksheet 4**

Annual travel time costs

	Period	1	2	3	4
	Period start year	2	8	14	20
	Period end year	7	13	19	25
	Mid point at end of year	4	10	16	22
	Duration of period	6	6	6	6
1	**Do minimum travel time cost at midpoint**				
2	**Option travel time cost at midpoint**				
		c^1	**c^2**	**c^3**	**c^4**
3	**Midpoint benefits (1) – (2)**				

4 PV travel time cost savings

[(**c^1** x 6 x 0.68) + (**c^2** x 6 x 0.39) + (**c^3** x 6 x 0.22) + (**c^4** x 6 x 0.12)] = $ _____ **C**

Transfer PV travel time cost savings, **C** for the preferred option to **C** on worksheet 1

SP5 Isolated intersection improvements, continued

Explanation for worksheet 5 **Vehicle operating cost savings**

This worksheet is used for calculating vehicle operating cost savings from modifying or changing the control of an intersection eg, from priority control to traffic signals. Intersection analysis requires modelling to be used for both the do minimum and project option.

The annual VOC for the do minimum and the project option are to be calculated either using direct output from a suitable computer programme (such as SIDRA, INTANAL or SCATES) or by aggregating outputs for representative time periods. Output and notes should be attached. Alternatively, fill in the tables in worksheet 5 as per the instructions below.

For intersections, VOC are not directly proportional to growth in traffic volumes. Hence, the calculations of VOC savings are undertaken in six yearly steps and the discounted values are summed to more accurately reflect the savings over the 25 year evaluation period.

The VOC calculations start at the beginning of year 2 (following completion of construction works in year 1) and finish at the end of year 25.

For each six year time period:

1. Enter the value of the VOC at the mid-point for the do minimum **(1)**. For example, in the first six year period (years 2 – 7), the end of year 4 is the mid-point; in years 20 – 25, the mid-point is the end of year 22.
2. Enter the value of the VOC at the mid-point for the project option **(2)**.
3. Calculate the 'mid-point benefits' **(3)** by subtracting the option VOC **(2)** from the do minimum VOC **(1)** from to obtain $\mathbf{c^1}$, $\mathbf{c^2}$, $\mathbf{c^3}$, and $\mathbf{c^4}$.
4. Using the formula provided, calculate the PV of the VOC and CO_2 benefits for the project option **D**. In the formula, each mid-point benefit value is multiplied by 6 to obtain the 6 yearly total, which is then discounted to get the PV for each 6 year interval. The results for each 6 year period are summed and multiplied by a factor of 1.075 to account for CO_2, to obtain the PV total VOC and CO_2 savings, **D**. Transfer **D** for the preferred option to worksheet 1.

SP5 Isolated intersection improvements, continued

Vehicle operating cost savings **Worksheet 5**

Annual VOC

	Period	1	2	3	4
	Period start year	2	8	14	20
	Period end year	7	13	19	25
	Mid point at end of year	4	10	16	22
	Duration of period	6	6	6	6
1	**Do minimum VOC at midpoint**				
2	**Option VOC at midpoint**				
		c^1	**c^2**	**c^3**	**c^4**
3	**Midpoint benefits (1) – (2)**				

4 PV VOC and CO_2 savings

[(**c^1** x 6 x 0.68) + (**c^2** x 6 x 0.39) + (**c^3** x 6 x 0.22) + (**c^4** x 6 x 0.12)] x 1.075 = $ _____ **D**

Transfer PV of VOC and CO_2 savings, **D** for the preferred option to **D** on worksheet 1

SP5 Isolated intersection improvements, continued

Explanation for worksheet 6 **Accident cost savings**

These simplified procedures are 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 worksheet 1 as total **E**.

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)**.
9. 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)**.
10. 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)**.
11. 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)**.
12. 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)**.
13. Calculate the annual accident cost savings by subtracting the values in **(26)** from **(17)**. Multiply the annual accident cost savings **(27)** – or the total from the accident rate or weighted accident analysis – by the discount factor in table 1 for the appropriate speed limit and traffic growth rate to determine the PV accident cost savings. Transfer this total, **E** for the preferred option to worksheet 1.

Table 1 Accident cost discount factor (DF^{AC}) for different traffic growth rates and speed limits for years 2 to 25 inclusive

Traffic growth rate	0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%
50 and 60 km/h	6.31	6.69	7.07	7.44	7.82	8.19	8.57	8.95	9.32
≥ 70 km/h	7.82	8.19	8.57	8.95	9.32	9.70	10.07	10.45	10.83

SP5 Isolated intersection improvements, continued

Accident cost savings **Worksheet 6**

	Movement category		Vehicle involvement	
1	Do minimum mean speed		Road category	
	Posted speed limit		Traffic growth rate	
2	Option mean speed			

	Do minimum	**Severity**			**Non-injury**
		Fatal	**Serious**	**Minor**	
3	Number of years of typical accident rate records				
4	Number of reported accidents over period				
5	Fatal/serious severity ratio (tables A6.19(a) to (c))			1	1
6	Number of reported accidents adjusted by severity **(4)** × **(5)**				
7	Accidents per year = **(6)**/**(3)**				
8	Adjustment factor for accident trend (table A6.1(a))				
9	Adjusted accidents per year = **(7)** x **(8)**				
10	Under-reporting factors (tables A6.20(a) and (b))				
11	Total estimated accidents per year = **(9)** x **(10)**				
12	Accident cost, 100 km/h limit (tables A6.21(e) to (h))				
13	Accident cost, 50 km/h limit (tables A6.21(a) to (d))				
14	Mean speed adjustment = (**(1)** - 50)/50				
15	Cost per accident = **(13)** + **(14)** x [**(12)** – **(13)**]				
16	Accident cost per year = **(11)** x **(15)**				
17	Total cost of accidents per year (sum of columns in row **(16)** fatal + serious + minor + non-injury) $				
	Option				
18	Percentage accident reduction				
19	Percentage of accidents 'remaining' [100 – **(18)**]				
20	Predicted accidents per year **(11)** x **(19)**				
21	Accident cost, 100km/h speed limit (tables A6.21(e) to (h))				
22	Accident cost, 50km/h speed limit (tables A6.21(a) to (d))				
23	Mean speed adjustment = (**(2)** - 50)/50				
24	Cost per accident = **(22)** + **(23)** x [**(21)** – **(22)**]				
25	Accident cost per year = **(20)** x **(24)**				
26	Total cost of accidents per year (sum of columns in row **(25)** fatal + serious + minor + non-injury) $				
27	Annual accident cost savings = **(17)** – **(26)** $				
28	PV accident cost savings = **(27)** x DF^{AC} $				**E**

Transfer PV of accident cost savings, **E** for the preferred option to **E** on worksheet 1

SP5 Isolated intersection improvements, continued

Explanation for worksheet 7 **BCR and incremental analysis**

Cost benefit analysis

1. Under benefits, enter the PVs for the benefits for the do minimum and for each option. Then subtract the benefits for the options from the benefits for the do minimum to get the net benefits for each option.
2. Under costs, enter the PVs for the capital, maintenance and operating costs for the do minimum and each option. Subtract the PV costs for the do minimum from the costs for each of the options to get the net costs of each option.
3. Calculate the national BCR by dividing the net benefits by the net costs.

Incremental analysis

1. Select the appropriate target incremental BCR from appendix A12.4.
2. Rank the options in order of increasing cost.
3. Compare the lowest cost option with the next higher cost option to calculate the incremental BCR.
4. If the incremental BCR is less than the target incremental BCR, discard the second option in favour of the first and compare the first option with the next higher cost option.
5. If the incremental BCR is greater than the target incremental BCR, the second option becomes the basis for comparison against the next higher cost option.
6. Repeat the procedure until no higher cost options are available that have an incremental BCR greater than the target incremental BCR. The highest cost option with an incremental BCR greater than the target incremental BCR is generally the preferred option.

SP5 Isolated intersection improvements, continued

BCR and incremental analysis **Worksheet 7**

Time zero _____

Base date _____

BCR_N	Do minimum	Option A	Option B	Option C	Option A	Option B	Option C
	PV of benefits as calculated				**PV of net benefits**		
Travel time cost savings							
VOC and CO_2 savings							
Accident cost savings							
PV total net benefits							
	PV of costs as calculated				**PV of net costs**		
Capital costs							
Maintenance costs							
PV total net costs							
BCR_N							

Target incremental BCR (from appendix A12.4) _____

Base option for comparison			**Next higher cost option**			**Incremental analysis**		
Option	**Total costs (1)**	**Total benefits (2)**	**Option**	**Total costs (3)**	**Total benefits (4)**	**Incremental costs (5)=(3)-(1)**	**Incremental benefits (6)=(4)-(2)**	**Incremental BCR_N (7)=(6)/(5)**