5 Case studies

The case studies provide an instructional guide for undertaking a road evaluation using CBA6. Projects can vary in complexity and CBA6 has a number of different modules that are used to evaluate a variety of road projects. CBA6 has been designed to encompass the types of capital and maintenance projects usually undertaken by TMR. Each case study provides an opportunity for system users to quickly become familiar with operating the tool.

Case studies have been included in this section for the following types of projects:

- maintenance strategies
- road widening
- shoulder sealing
- overtaking lanes
- flood immunity and road closures
- intersections
- duplication
- town bypasses
- unsealed roads
- generated traffic
- freight
- multiple project options
- incremental analysis
- linking evaluation files.

Note: Detailed printed reports for each case study are presented in Appendix A (CBA6.1 printouts).

The explanation of the case studies are accompanied by detailed instructions on entering project data into CBA6 together with guidance on project results.

5.1 Maintenance

This case study provides guidance to undertake a maintenance strategy evaluation. A maintenance evaluation will primarily compare the roughness deterioration profile between the base and project cases and the ensuing change in maintenance costs. It is sometimes required, when bringing forward some maintenance work, to delay other work. CBA6 can be used to calculate the net economic benefits of mutually exclusive maintenance programs.

TMR's asset management guidelines (2002) prescribe three categories of maintenance:

- routine maintenance
- programmed maintenance – road resurfacing and/or bulk routine maintenance
- rehabilitation.

In CBA6 programmed maintenance is referred to as 'periodic maintenance'.

5.1.1 Maintenance case study

This case study involves the evaluation of a narrow two-lane road with pavement in fair condition. The road has low traffic volumes but there is a large proportion of heavy commercial vehicles that make up the traffic fleet. The characteristics of the road may not justify the capital costs due to low traffic volumes, but TMR wants to test an alternative maintenance strategy that will better cater for the heavy vehicles using the road.

The current maintenance strategy for the road consists of annual routine maintenance and periodic maintenance in Years 5, 10, 15, 20, 25 and 29. The periodic maintenance works will improve the road surface by 5 NRM.

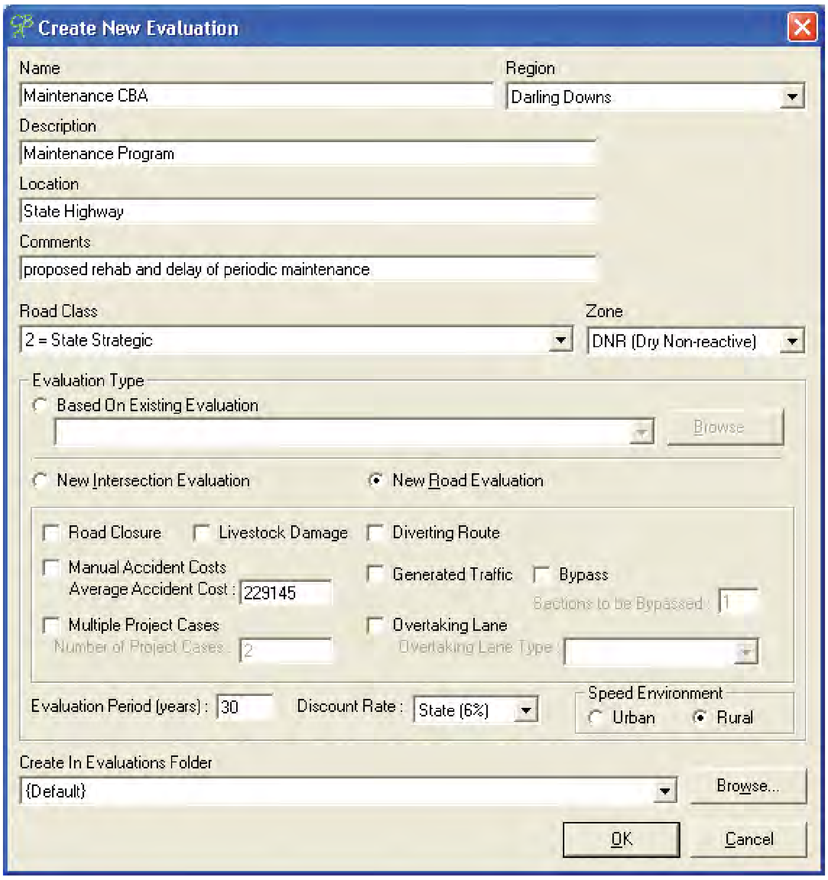
The objective of this CBA is to determine the economic viability of pursuing the new maintenance program in place of the current program. All the required input data for this maintenance case study can be found in Appendix A.

Figure 63: Maintenance case study NRM

5.1.2 Create new evaluation screen

Figure 64 shows the maintenance case study evaluation details screen. The key attributes of this screen are the selection of the discount rate, the evaluation period, the zone and the speed environment. The remaining details in the 'create evaluation' screen are superfluous and can be entered according to the system user's own preference.

Figure 64: Maintenance create new evaluation



5.1.3 Road details screen

The data entered into the 'road details' screen for the base case and project case are the same. Enter an MRS of 8, a section length of 2 km, an initial roughness of 80 NRM, a safe speed of 80 km/h, a pavement type of flexible, a surface type of sprayed seal, a straight horizontal alignment and a vertical alignment of rolling and undulating. For a maintenance only evaluation the road details for the base and project cases should remain the same.

5.1.4 Road traffic data screen

The road traffic data is the same for the base case and the project case. The AADT is 2500 in Year 1; the growth rate is 2.0% and linear. Traffic breakdown is 73% cars – private, 5% cars – commercial, 5% non-articulated, 0% buses, 5% articulated, 8% B-doubles, 3% road train type 1 and 1% road train type 2.

5.1.5 Capital and maintenance costs

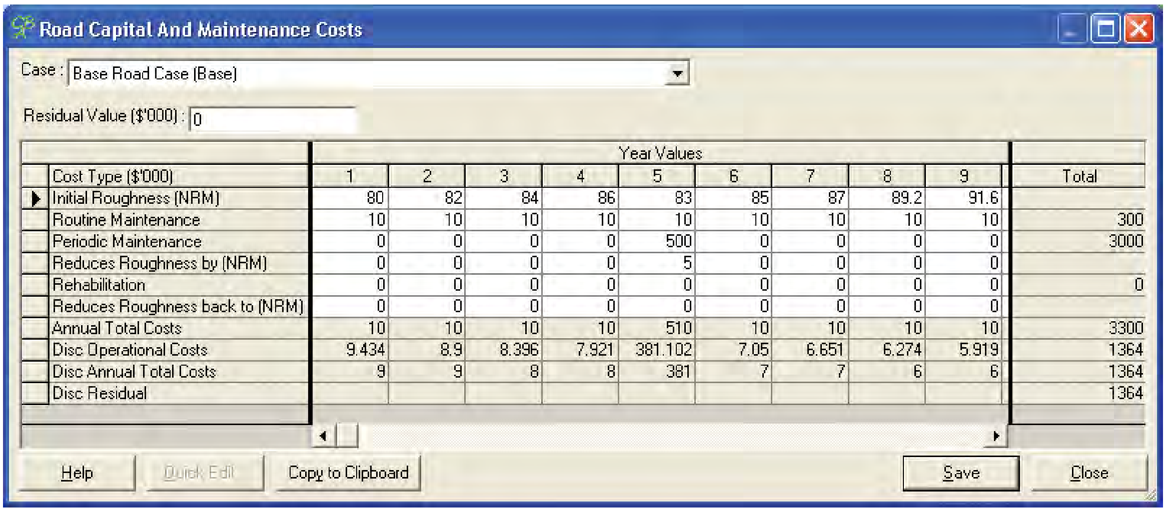
The most important inputs for a maintenance evaluation are found in the 'capital and maintenance costs' screen. Assumptions and data for the maintenance strategy will differ between the base and project cases.

5.1.5.1 Base case

Base case maintenance costs are shown in Figure 65.

Routine maintenance – enter $10 000 each year. Routine maintenance is work carried out each year that does not change the condition of the road NRM, such as grass cutting and road kill clean up. Use the 'quick edit' button to populate the routine maintenance fields for the entire evaluation period. The 'quick edit' buttons are explained in detail in Section 3.6.7. Note: If the base case and project case routine maintenance costs are the same, they do not need to be entered in CBA6. Periodic maintenance – enter $500 000 in Years 5, 10, 15, 20, 25 and 29 in the 'periodic maintenance' row. Enter a reduction in roughness by 5 NRM in the 'reduces roughness by (NRM)' row to correspond with the periodic maintenance costs. Periodic maintenance will provide a temporary improvement in the road's surface but roughness will deteriorate at a faster rate than if rehabilitation had taken place. Rehabilitation – $0, no reconstruction in the base case. The current maintenance strategy only provides periodic maintenance. Once all the maintenance data has been entered in CBA6, click 'save' and begin the same procedure for the project case. In the project case, the assumptions on the timing of periodic maintenance will change and rehabilitation will now be included in CBA6.

Figure 65: Maintenance case study base case


Road Capital And Maintenance Costs

Case : Base Road Case (Base)

Residual Value ($'000) : 0

Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	80	82	84	86	83	85	87	89.2	91.6	
Routine Maintenance	10	10	10	10	10	10	10	10	10	300
Periodic Maintenance	0	0	0	0	500	0	0	0	0	3000
Reduces Roughness by (NRM)	0	0	0	0	5	0	0	0	0	
Rehabilitation	0	0	0	0	0	0	0	0	0	0
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0	0	
Annual Total Costs	10	10	10	10	510	10	10	10	10	3300
Disc Operational Costs	9.434	8.9	8.396	7.921	381.102	7.05	6.651	6.274	5.919	1364
Disc Annual Total Costs	9	9	8	8	381	7	7	6	6	1364
Disc Residual										1364

5.1.5.2 Project case

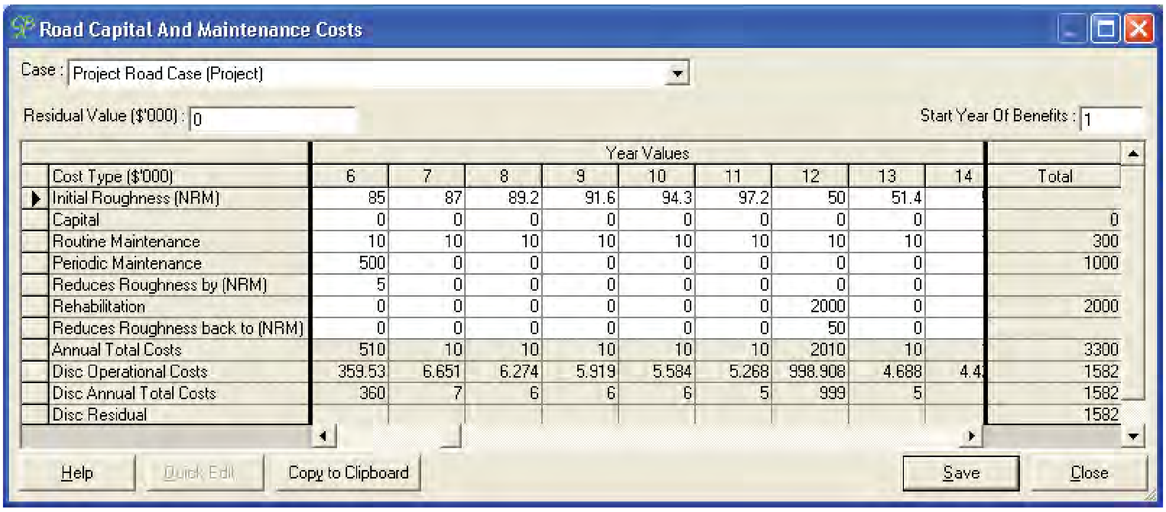
Project case maintenance costs are shown in Figure 65.

- Capital – $0, no capital costs for a maintenance strategy.
- Routine maintenance – in this example, routine maintenance does not change for the project case, so use $10 000 for each year. Note: If the base case and project case routine maintenance costs are the same they do not need to be entered in CBA6 as the net result will be zero.
- Periodic maintenance – $500 000 in Years 6 and 28 with corresponding roughness reduction of 5 NRM.
- Rehabilitation – enter $2 million in Year 12 in the 'rehabilitation' row. As in Figure 64 enter a new roughness of 50 NRM in the 'reduces roughness to (NRM)' row to correspond with the rehabilitation costs. Rehabilitation will provide a more permanent improvement to road roughness than periodic maintenance. After rehabilitation, roughness will deteriorate at a slower rate than if periodic maintenance had just been applied.
- Start year of benefits – this is only available for the project case. This value defaults to 1, but changes to the year of the last entered capital cost plus 1. A maintenance strategy can be tested from Year 1.

- Residual value – this evaluation does not have a residual value, as capital costs have not been incurred in this project. For information regarding residual value refer to Section 3.6.5.

Once all the maintenance data has been entered into CBA6 click ‘save’. Click ‘copy to clipboard’ to create a graph of the maintenance and roughness deterioration profile in a spreadsheet. This is useful to provide a simple visual comparison of the base and project cases.

Figure 66: Maintenance case study project case



	Year Values									
Cost Type ($'000)	6	7	8	9	10	11	12	13	14	Total
Initial Roughness (NRM)	85	87	89.2	91.6	94.3	97.2	50	51.4		
Capital	0	0	0	0	0	0	0	0		0
Routine Maintenance	10	10	10	10	10	10	10	10		300
Periodic Maintenance	500	0	0	0	0	0	0	0		1000
Reduces Roughness by (NRM)	5	0	0	0	0	0	0	0		
Rehabilitation	0	0	0	0	0	0	2000	0		2000
Reduces Roughness back to (NRM)	0	0	0	0	0	0	50	0		
Annual Total Costs	510	10	10	10	10	10	2010	10		3300
Disc Operational Costs	359.53	6.651	6.274	5.919	5.584	5.268	998.908	4.688	4.4	1582
Disc Annual Total Costs	360	7	6	6	6	5	999	5		1582
Disc Residual										1582

5.1.6 Accident and other costs

It has been assumed in CBA6, that pure maintenance strategies do not influence accident costs.

5.1.7 Results and decision criteria

The ‘results’ screen in Figure 66 provides the system user with information as to which maintenance strategy provides greater economic value.

The project case maintenance strategy requires higher maintenance costs, in the order of $218 095, than the base case maintenance strategy, at a discount rate of 6%. No capital was applied to this evaluation. The increase in maintenance costs is justified, as the benefits for existing road users are greater than the increase in maintenance costs. The majority of the project benefits are comprised of VOC savings for commercial vehicles. The results imply that the project satisfies the objective of catering better for heavy vehicles using the road. The NPV for the proposed maintenance strategy is $197 711 at the discount rate of 6%. The BCR for our new maintenance strategy is 1.91 at the discount rate of 6%, which indicates a positive economic return on the costs. The BCR produced for maintenance strategies should not be used in comparison with capital projects, see Section 3.5.3.2.

The alternative maintenance strategy in this case study is a better option than the existing strategy. CBA6 can compare a number of mutually exclusive options using the ‘multiple project cases’, see Section 5.11. This module provides a guide to undertaking multiple options analysis. This will be useful in developing the optimum maintenance strategy for the road network.

Figure 67: Maintenance case results

Results - Decision Criteria Recalc No 9

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	208,635	218,095	212,890	203,813	179,252
Discounted Capital Costs	0	0	0	0	0
Discounted Other Costs	208,635	218,095	212,890	203,813	179,252
Discounted Benefits	621,026	415,806	342,389	283,071	195,722
Private TTC Savings	0	0	0	0	0
Commercial TTC Savings	213,707	142,895	117,613	97,208	67,200
Private VOC Savings	128,869	85,922	70,584	58,209	40,029
Commercial VOC Savings	278,450	186,990	154,193	127,654	88,493
Discounted Accident Savings	0	0	0	0	0
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	412,391	197,711	129,500	79,258	16,469
Net Present Value per dollar Investment	0.00	0.00	0.00	0.00	0.00
Benefit Cost Ratio Excl. Private Time	2.98	1.91	1.61	1.39	1.09
Benefit Cost Ratio	2.98	1.91	1.61	1.39	1.09
First Year Rate of Return	0.00%	0.00%	0.00%	0.00%	0.00%

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5.2 Road widening

A road widening project involves increasing the seal width of the road. Road widening projects are designed to alleviate minor congestion issues and provide a safer operating environment for road users. For the purposes of conducting evaluations using CBA6, road widening projects have been divided into two categories.

- Section 5.2.1 – road widening without shoulder sealing
- Section 5.2.2 – road widening with shoulder sealing

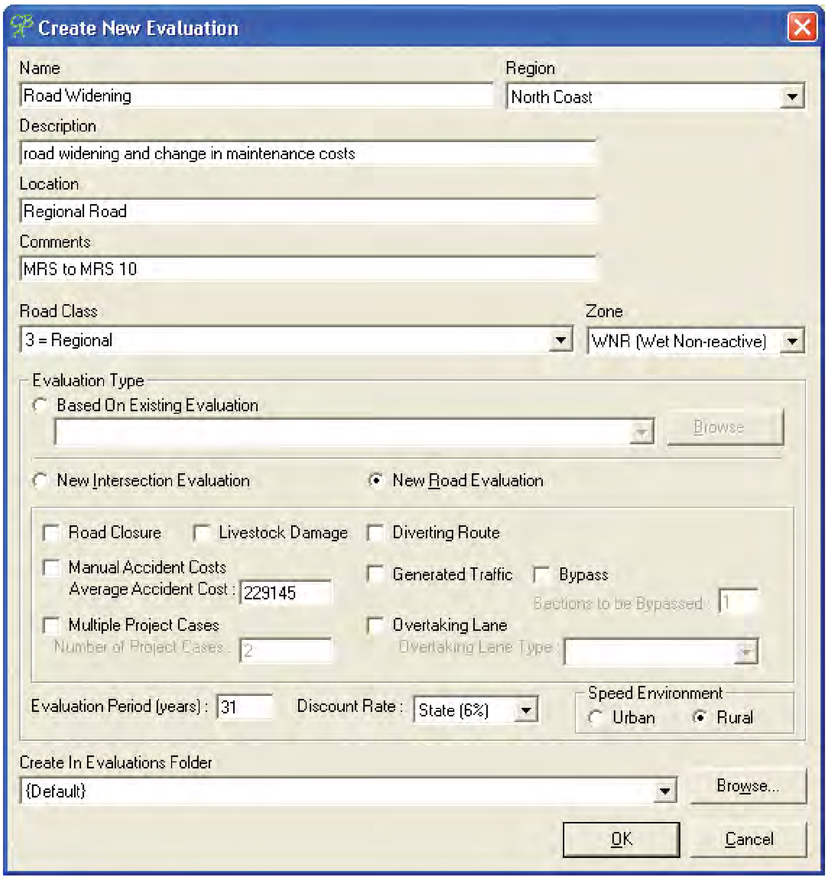
5.2.1 Road widening without shoulder sealing

This example involves the evaluation of a regional road with a poor safety record. A road widening is proposed to mitigate the higher than average accident rate. The proposed road widening will increase the seal width from a model road state MRS 7 (two-lane seal 5.3 m– 5.8 m) to MRS 10 (two-lane seal 7.1 m – 7.6 m), both of which do not provide sealed shoulders. The proposed road widening is expected to cost $2.5 million and take one year to complete.

5.2.1.1 Create new evaluation screen

The 'create new evaluation' screen for this case study is shown in Figure 68. The evaluation period is set to 31 years. There will be one year of construction and a useful life of 30 years for the asset. In this example it may be appropriate to provide comment on the widening work being proposed in the 'description' field.

Figure 68: Road widening case study



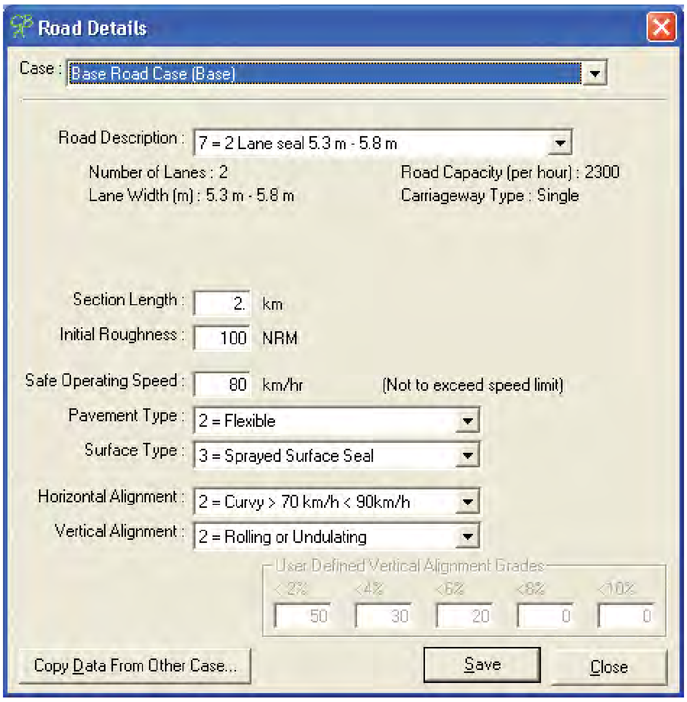
5.2.1.2 Road details

The 'road details' screen highlights the important difference between the base and project cases. In a simple road widening project the most important inputs to CBA6 will be in the description of model road state.

5.2.1.2.1. Base case

The base case road details are shown in Figure 69. The base case 'road description' is an MRS of 7. The current roughness of the road is 100 NRM. The pavement and surface type have been defaulted to match the MRS of 7. Once the 'road details' screen for the base case is complete, click 'save'.

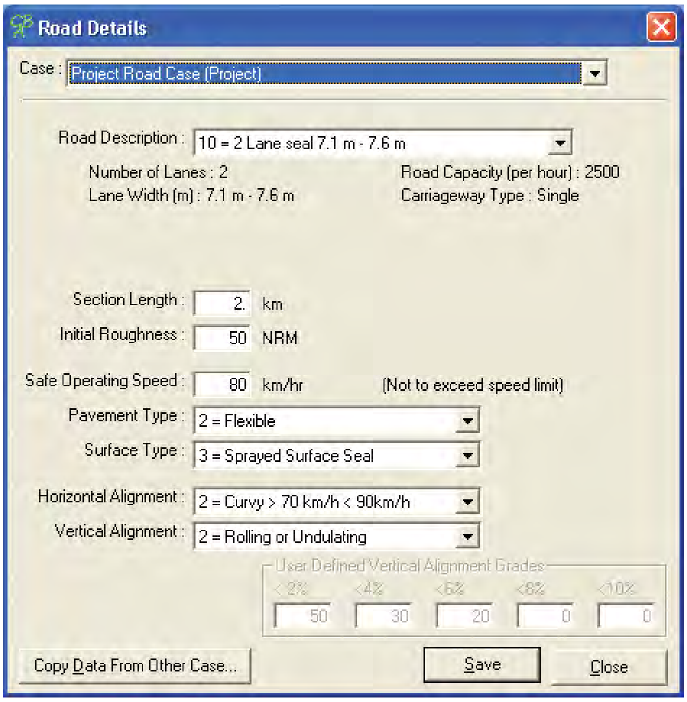
Figure 69: Road widening base case



5.2.1.2.2. Project case

The only change to the 'road details' screen for the project case in this simple widening will be the MRS and initial roughness, see Figure 70. To quickly populate the project case road details screen press the 'copy data from other case' button and use the base case road details. Once all the base case details have been copied over, change the MRS using the drop-down menu. The MRS in the project case should be 10 (two-lane seal 7.1 m – 7.6 m). The initial roughness in the project case is 50 NRM.

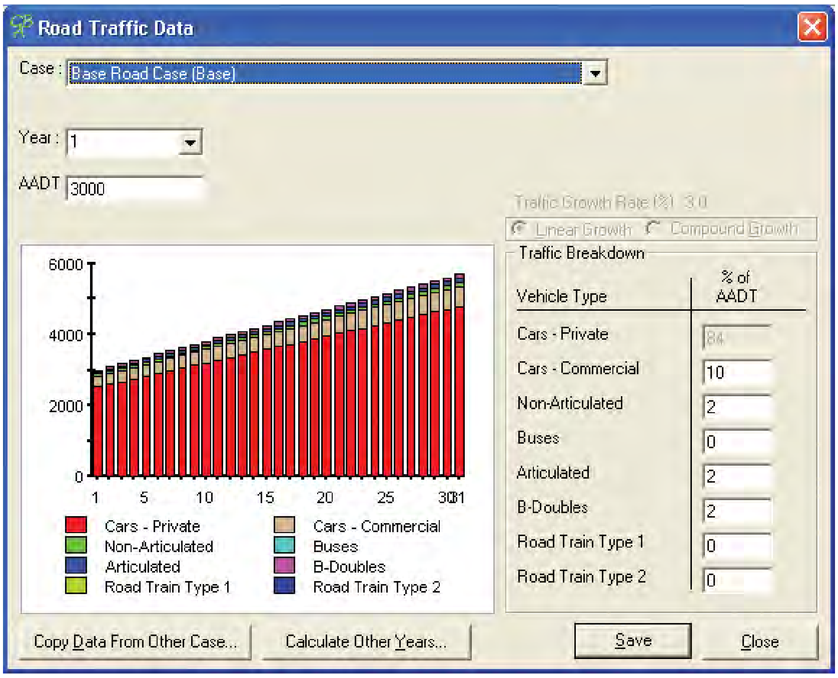
Figure 70: Road widening project case



5.2.1.3 Road traffic data

In this example, the AADT is 3000 vehicles per day, see Figure 71. Traffic data for the base and project cases will be the same. Once the base case traffic data has been saved, use the 'copy data from other case' button to quickly transfer the same data for the project case.

Figure 71: Road widening traffic data



5.2.1.4 Capital and maintenance costs

In this example, the project case has $2.5 million in capital costs. In this example it is necessary to change the maintenance profile for the project case.

5.2.1.4.1. Base case

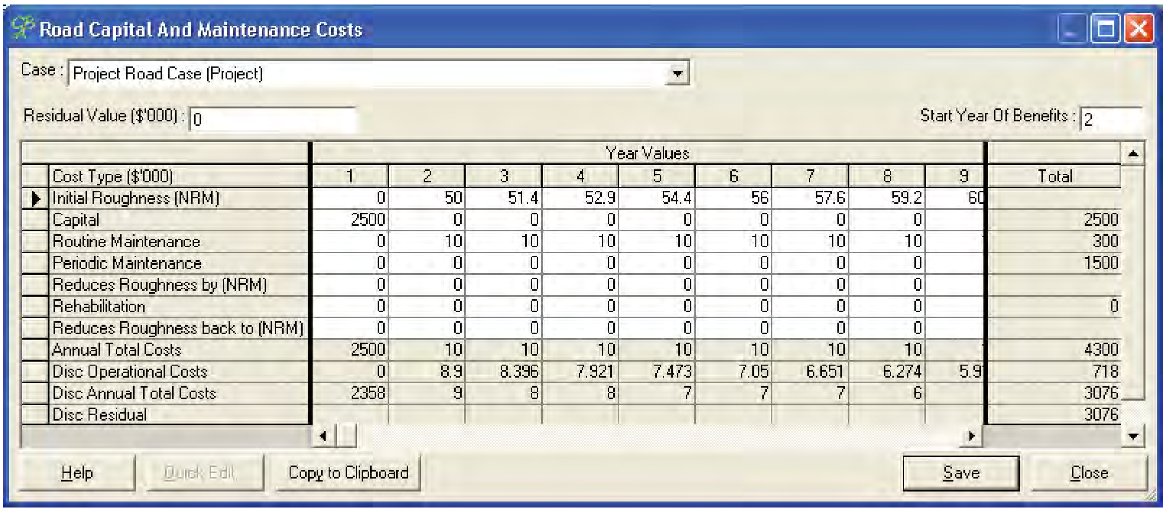
Routine maintenance – $10 000 each year. Routine maintenance is work carried out each year that does not change the condition of the road NRM, such as grass cutting and road kill clean up. Use the 'quick edit' to populate the routine maintenance fields for the entire evaluation period, see Section 3.6.7. Periodic maintenance – $500 000 in Years 7, 21 and 28 with corresponding roughness reduction of 5 NRM. Periodic maintenance (programmed maintenance) will provide a temporary improvement in the road's surface. Rehabilitation – $1 million in Year 14 that reduces roughness back to 80 NRM. The 'copy to clipboard' button may be used to copy the capital and maintenance cost data and paste into a suitable external program such as Excel. Once all the maintenance data has been applied in CBA6, click the 'save' button and begin the same procedure for the project case.

5.2.1.4.2. Project case

- Capital – $2.5 million entered in Year 1. CBA6 uses cost data in '000 – input 2500 in CBA6 to represent $2.5 million, see Figure 71.
- Routine maintenance – assume routine maintenance is the same as the base case, therefore input $10 000 each year.
- Periodic maintenance – the maintenance profile between the base and project cases now changes. Only three maintenance interventions are now required. Enter $500 000 in Years 10, 17, and 24 with corresponding roughness reduction of 5 NRM.
- Rehabilitation – $0, no reconstruction in the project case.

- Start year of benefits – this field is only available for the project case and will default to Year 1. As the benefits of the project will flow post construction, this default value needs to be changed to the year of the last entered capital cost plus one. For this case study the project will be assessed from Year 2.
- Residual value – there is no residual value of the asset after the 31-year evaluation period.
- The 'copy to clipboard' button may be used to copy the capital and maintenance cost data and paste into a suitable external program such as Excel.

Figure 72: Road widening project costs

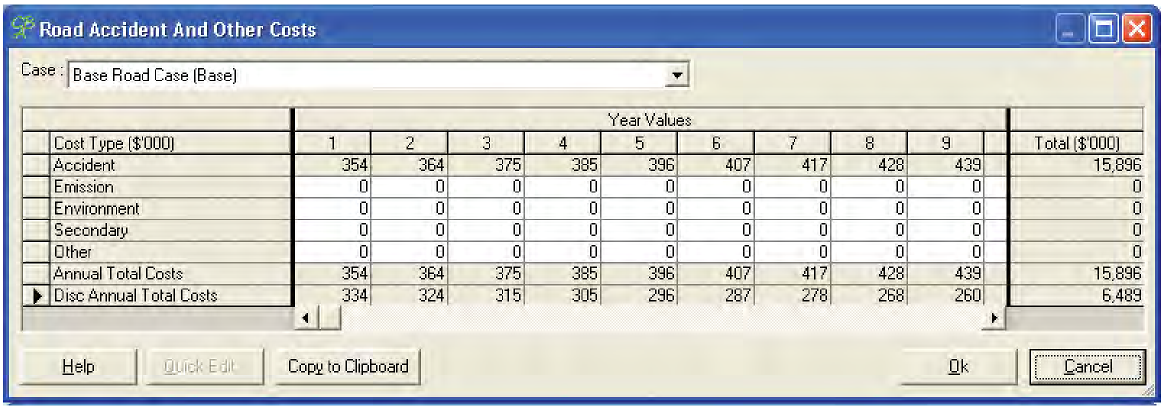


	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	50	51.4	52.9	54.4	56	57.6	59.2	60	
Capital	2500	0	0	0	0	0	0	0		2500
Routine Maintenance	0	10	10	10	10	10	10	10		300
Periodic Maintenance	0	0	0	0	0	0	0	0		1500
Reduces Roughness by (NRM)	0	0	0	0	0	0	0	0		
Rehabilitation	0	0	0	0	0	0	0	0		0
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	2500	10	10	10	10	10	10	10		4300
Disc Operational Costs	0	8.9	8.396	7.921	7.473	7.05	6.651	6.274	5.9	718
Disc Annual Total Costs	2358	9	8	8	7	7	7	6		3076
Disc Residual										3076

5.2.1.5 Accident and other costs

Safety is a major reason behind the planning and construction of road widening projects. This example involves the evaluation of a project which produces a significant reduction in accidents (see Section 6 of the *Technical Guide* for the relationship between MRS and accident rates). Accident costs decrease in the first year of the evaluation from $354 000 in the base case to only $190 000 in the project case, see Figures 73 and 74. If the accident cost estimates are not representative of the section of road analysed, the system user can manually calculate the accident costs. To manually calculate accident costs, the 'manual accident cost' box found in the 'create new evaluation' screen needs to be clicked.

Figure 73: Road widening accident costs – base case



	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total ($'000)
Accident	354	364	375	385	396	407	417	428	439	15,896
Emission	0	0	0	0	0	0	0	0	0	0
Environment	0	0	0	0	0	0	0	0	0	0
Secondary	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Annual Total Costs	354	364	375	385	396	407	417	428	439	15,896
Disc Annual Total Costs	334	324	315	305	296	287	278	268	260	6,489

Figure 74: Road widening accident costs – project case

Road Accident And Other Costs

Case : Project Road Case (Project)

Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total ($'000)
	Year Values									
Accident	190	196	201	207	213	219	224	230	236	8,544
Emission	0	0	0	0	0	0	0	0	0	0
Environment	0	0	0	0	0	0	0	0	0	0
Secondary	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Annual Total Costs	190	196	201	207	213	219	224	230	236	8,544
Disc Annual Total Costs	179	174	169	164	159	154	149	144	140	3,488

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5.2.1.6 Results and decision criteria

The estimated capital cost for this project is $2.5 million. As a result of capital works, TMR has been able to delay some programmed maintenance. The increase in spending is justified as benefits exceed the costs. Discounted benefits for existing road users are valued at over $3.3 million.

The majority of project benefits are derived from savings in accident costs totalling $2.8 million, see Figure 75. The results imply that the project satisfies the objective of reducing the frequency of accidents. At a discount rate of 6%, the NPV of the proposed maintenance strategy is over $1.4 million and the BCR is 1.72.

Figure 75: Road widening decision criteria

Results - Decision Criteria Recalc No 3

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	1,840,171	1,917,703	1,942,988	1,961,645	1,983,946
Discounted Capital Costs	2,403,846	2,358,491	2,336,449	2,314,815	2,272,727
Discounted Other Costs	-563,675	-440,787	-393,460	-353,169	-288,781
Discounted Benefits	4,312,983	3,291,466	2,908,203	2,587,616	2,088,383
Private TTC Savings	8,652	6,801	6,041	5,371	4,261
Commercial TTC Savings	78,523	62,962	56,782	51,425	42,652
Private VOC Savings	325,956	256,523	230,324	208,268	173,473
Commercial VOC Savings	150,153	118,547	106,565	96,451	80,439
Discounted Accident Savings	3,749,699	2,846,632	2,508,490	2,226,101	1,787,557
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	2,472,812	1,373,762	965,215	625,971	104,437
Net Present Value per dollar Investment	1.03	0.58	0.41	0.27	0.05
Benefit Cost Ratio Excl. Private Time	2.34	1.71	1.49	1.32	1.05
Benefit Cost Ratio	2.34	1.72	1.50	1.32	1.05
First Year Rate of Return	7.31%	7.17%	7.10%	7.04%	6.91%

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5.2.2 Road widening with shoulder sealing

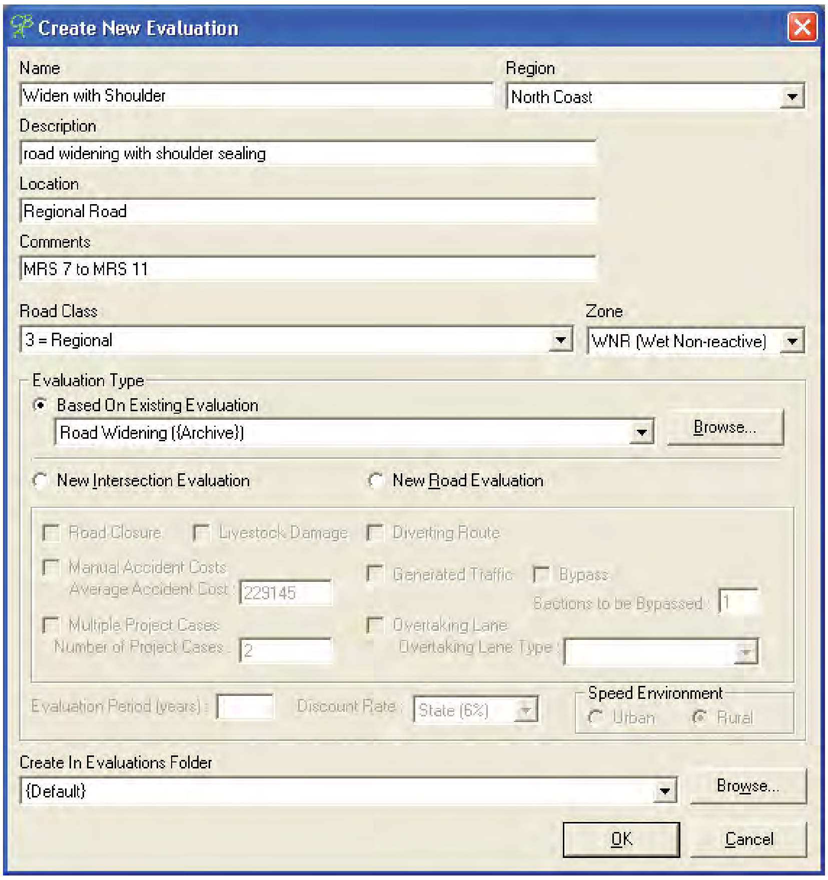
This case study will provide instruction on using CBA6 to conduct an evaluation of initiatives that involve both widening the road and providing a sealed shoulder.

5.2.2.1 Create new evaluation

The ‘create new evaluation screen’ is shown in Figure 76.

Note: ‘Based on existing evaluation’ option has been selected.

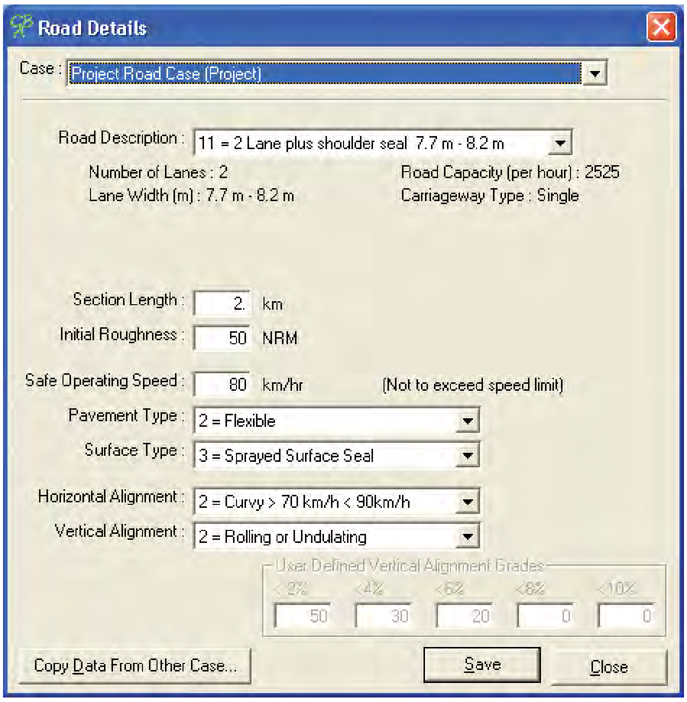
Figure 76: Road widening with shoulder sealing



5.2.2.2 Road details

The base case MRS is 7 (two-lane seal 5.3 m – 5.8 m without sealed shoulders). The project will widen the road to MRS 11 with sealed shoulders (two-lane seal 7.7 m – 8.2 m), see Figure 77.

Figure 77: Project case with sealed shoulders



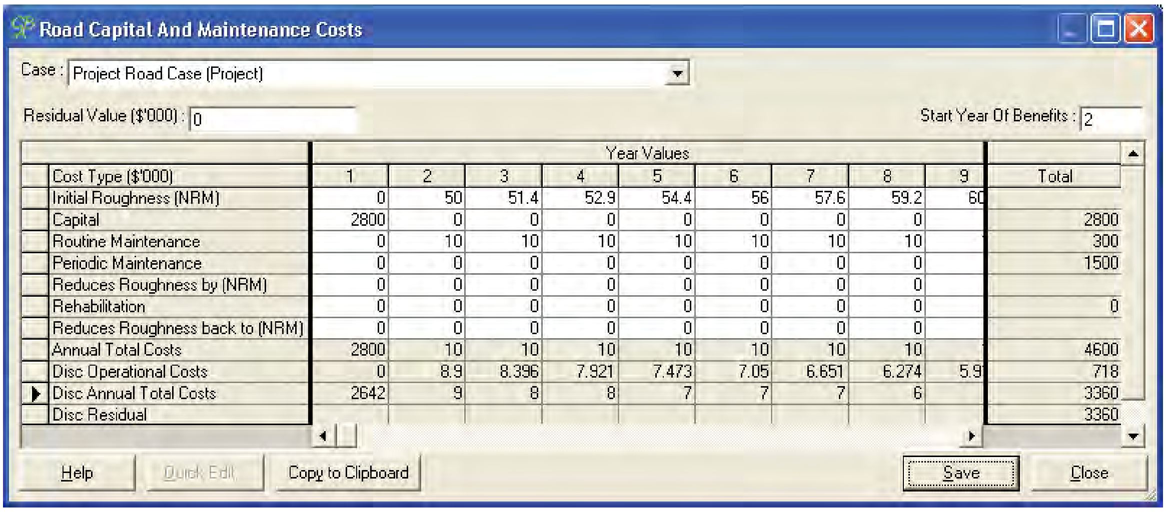
5.2.2.3 Road traffic data

Traffic volumes will remain unchanged from the previous case study which included AADT of 300 vehicles per day.

5.2.2.4 Capital and maintenance costs

The provision of sealed shoulders is expected to incur an additional $500 000 in costs. Capital costs for this project will be $3 million, see Figure 78. For simplicity, maintenance and ongoing costs have remained consistent with the previous case study. However, in some instances, the provision of sealed shoulders may actually increase ongoing costs.

Figure 78: Widen and shoulder seal costs


Road Capital And Maintenance Costs

Case : Project Road Case (Project)

Residual Value ($'000) : 0

Start Year Of Benefits : 2

	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	50	51.4	52.9	54.4	56	57.6	59.2	60	
Capital	2800	0	0	0	0	0	0	0		2800
Routine Maintenance	0	10	10	10	10	10	10	10		300
Periodic Maintenance	0	0	0	0	0	0	0	0		1500
Reduces Roughness by (NRM)	0	0	0	0	0	0	0	0		
Rehabilitation	0	0	0	0	0	0	0	0		0
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	2800	10	10	10	10	10	10	10		4600
Disc Operational Costs	0	8.9	8.396	7.921	7.473	7.05	6.651	6.274	5.9	718
Disc Annual Total Costs	2642	9	8	8	7	7	7	6		3360
Disc Residual										3360

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5.2.2.5 Accident and other costs

Accident rates for roads with sealed shoulders are usually lower than for roads without sealed shoulders. In this case study, it is assumed that accident cost savings will comprise a greater proportion of benefits than the previous case study.

5.2.2.6 Results and decision criteria

The results of this evaluation are shown in Figure 79. Total benefits for this project are $3.7 million at the 6% discount rate. In the previous case study, total benefits for the project were only $3.6 million. However the provision of sealed shoulders results in the BCR being lower than the BCR for the previous case study, and the project NPV at $1.56 million is higher than the previous case study that returned an NPV of $1.37 million. This result suggests that the additional funds to provide a sealed shoulder are economically justified in comparison to the previous case study. See Section 5.11 for further discussion on option analysis.

Figure 79: Road widen and shoulder seal decision criteria

Results - Decision Criteria Recalc No 3

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	2,128,632	2,200,722	2,223,362	2,239,423	2,256,673
Discounted Capital Costs	2,692,308	2,641,509	2,616,822	2,592,593	2,545,455
Discounted Other Costs	-563,675	-440,787	-393,460	-353,169	-288,781
Discounted Benefits	4,926,657	3,757,222	3,318,583	2,951,755	2,380,722
Private TTC Savings	8,652	6,801	6,041	5,371	4,261
Commercial TTC Savings	78,523	62,962	56,782	51,425	42,652
Private VOC Savings	330,213	259,662	233,052	210,655	175,342
Commercial VOC Savings	151,511	119,549	107,436	97,213	81,036
Discounted Accident Savings	4,357,758	3,308,248	2,915,272	2,587,091	2,077,432
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	2,798,025	1,556,500	1,095,221	712,332	124,049
Net Present Value per dollar Investment	1.04	0.59	0.42	0.27	0.05
Benefit Cost Ratio Excl. Private Time	2.31	1.70	1.49	1.32	1.05
Benefit Cost Ratio	2.31	1.71	1.49	1.32	1.05
First Year Rate of Return	7.47%	7.33%	7.26%	7.19%	7.06%

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5.3 Realignment

Road alignment can impact on vehicle speed and also trafffic volume. Realignment projects are designed to improve unnecessary bends and make the road safer to traverse, and can be applied to the approaches of existing bridge structures and also to roads with poor design standards. In some cases realignment projects shorten the distance road users have to travel. Realignment projects that improve the horizontal alignment of the road could provide substantial TTC savings and accident cost savings.

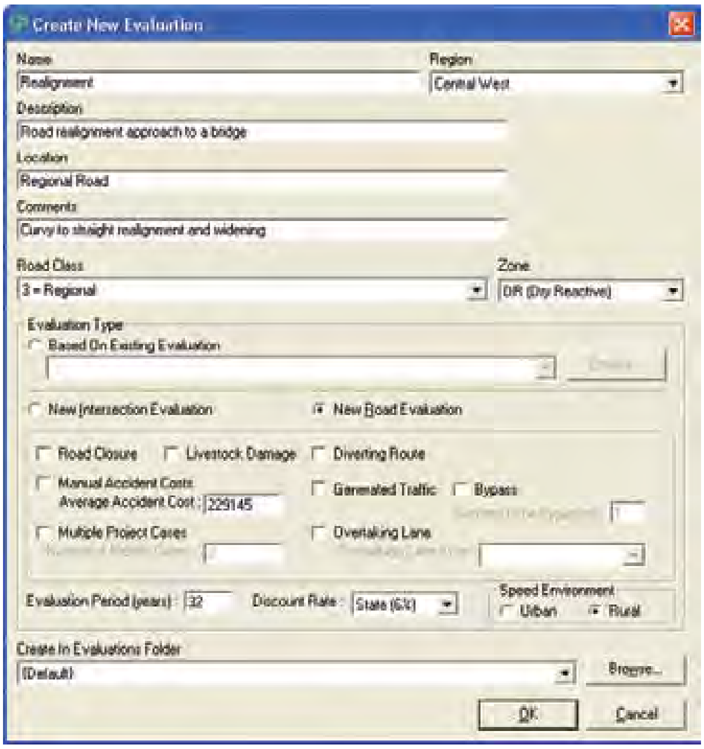
5.3.1 Realignment case study

A regional road is curvy and only provides safe operating speeds of up to 80 kilometres per hour. The aim of this project is to straighten the alignment to allow for an increase in the posted speed limit. The new posted speed will be 100 kilometres per hour. Construction of this project will occur over two years and will reduce the road length from 2.5 kilometres to 2.3 kilometres.

5.3.2 Create new evaluation

To create a new evaluation, enter a road class of regional, a zone of dry reactive, an evaluation period of 32 years and a discount rate of 6% in the 'create new evaluation' screen. The boxes for advanced projects should not be ticked, see Figure 80.

Figure 80: Realignment case study



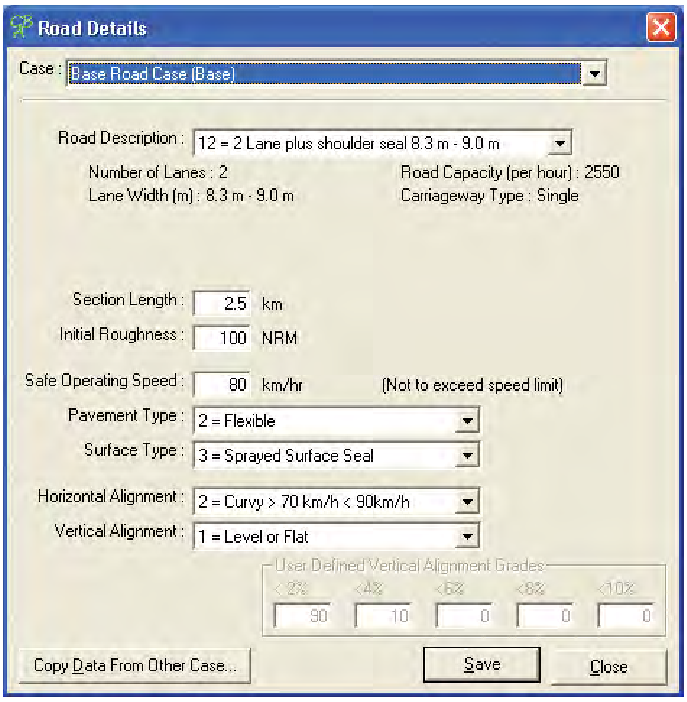
5.3.3 Road details

The 'road details' screens highlight the important difference between the base and project cases. In this example the horizontal alignment of the base case is specified as curvy while in the project case the new road design caters for speeds over 90 km/h. The project case horizontal alignment will be straight.

5.3.3.1 Base case

The base case road details are shown in Figure 81. The current horizontal alignment in the base case is curvy (please refer to Section 4.3 of the *Technical Guide* for tyre wear curvature parameters for curvy and very curvy roads).

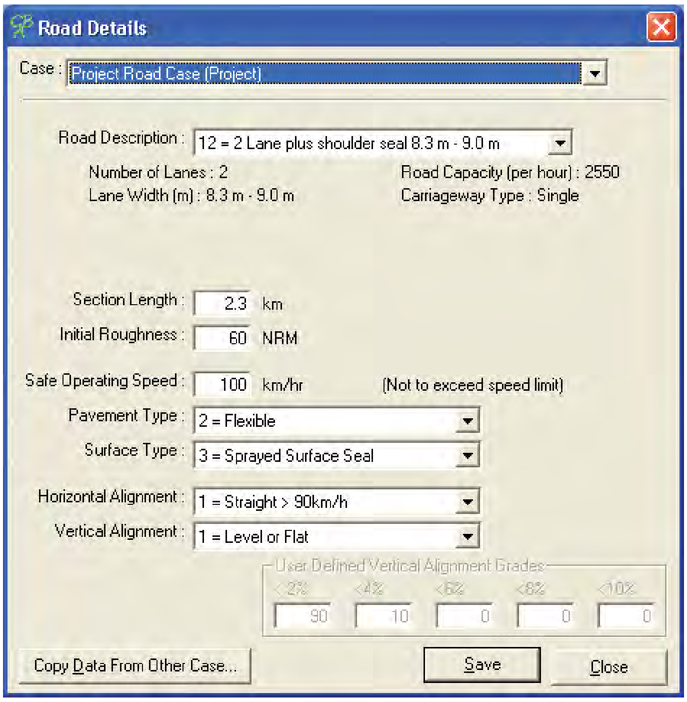
Figure 81: Realignment base case



5.3.3.2 Project case

For the project case use the ‘copy data from other case’ button to transfer the data from main case. The following changes need to be made to the project case: Section length – as a result of the realignment the road has been shortened. The new section length is 2.3 km. The input with the largest influence on the benefits for this case study is the horizontal alignment. The project case will improve the road from curvy to straight. Figure 82 shows the road details for the realigned project case.

Figure 82: Realignment project case



5.3.4 Road traffic data

The road traffic data is the same for the base case and the project case. The AADT is 5000 in Year 1; the growth rate is 4% and compound. Traffic breakdown is 85% private cars, 5% commercial cars, 4% non-articulated, 2% buses, 2% articulated, 2% B-doubles, 0% road train type 1 and 0% road train type 2.

5.3.5 Capital and maintenance costs

The proposed project will have a construction timeframe of two years. Construction will occur in Year 2 with detailed design and minor works to be undertaken in Year 1. The maintenance strategy will also differ between the base and project cases.

5.3.5.1 Base case

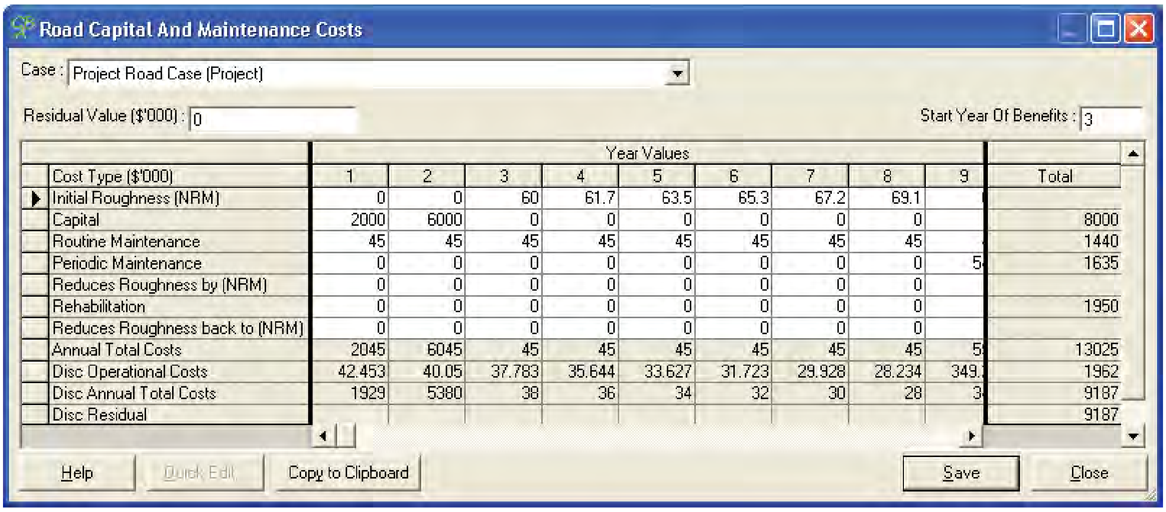
Routine maintenance – enter $50 000 each year. Use the ‘quick edit’ button to populate the routine maintenance fields for the entire evaluation period. Periodic maintenance – enter $550 000 in Years 7, 21 and 28 in the ‘periodic maintenance’ row. Enter a reduction in roughness by 5 NRM in adjoining years. Rehabilitation – the current maintenance strategy for the road involves reconstruction costs of $2 million in Year 14. The roughness of the road will be reduced back to 50 NRM. Once all the maintenance data has been entered into CBA6 click ‘save’ and begin the same procedure for the project case.

5.3.5.2 Project case

For the project case enter the following:

Capital – the total cost for the project is $8 million. In Year 1 the costs will be $2 million with the remainder spent in Year 2. Routine maintenance – assume routine maintenance will be lower in the project case given there is less road to maintain. Routine maintenance will be $45 000 per annum. Periodic maintenance – $545 000 in Years 9, 23 and 30 with corresponding roughness reduction of 5 NRM. Rehabilitation – enter $1.95 million in Year 16 of the 'rehabilitation' row. Enter a new roughness of 50 NRM in the 'reduces roughness to (NRM)' row to correspond with the rehabilitation costs. Start year of benefits – the start year of benefits will be in Year 3. Residual value – this evaluation does not have a residual value. Once all the maintenance data has been entered in CBA6 click 'save'. Use the 'copy to clipboard' button to graph the maintenance and roughness deterioration profile in a spreadsheet. This is useful when comparing the base and project cases. Figure 83 shows the capital and maintenance costs for the realignment project case.

Figure 83: Realignment costs

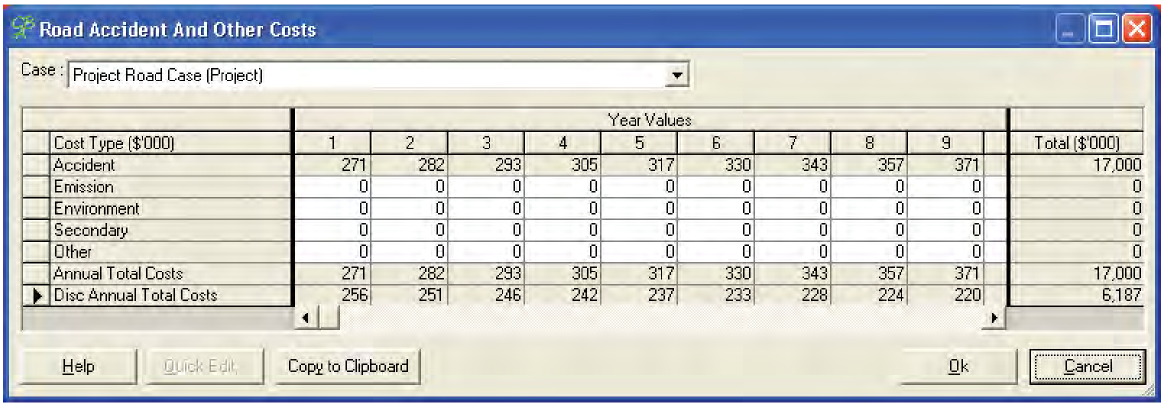


Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	0	60	61.7	63.5	65.3	67.2	69.1		
Capital	2000	6000	0	0	0	0	0	0		8000
Routine Maintenance	45	45	45	45	45	45	45	45		1440
Periodic Maintenance	0	0	0	0	0	0	0	0	5	1635
Reduces Roughness by (NRM)	0	0	0	0	0	0	0	0		
Rehabilitation	0	0	0	0	0	0	0	0		1950
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	2045	6045	45	45	45	45	45	45	5	13025
Disc Operational Costs	42.453	40.05	37.783	35.644	33.627	31.723	29.928	28.234	349.	1962
Disc Annual Total Costs	1929	5380	38	36	34	32	30	28	3	9187
Disc Residual										9187

5.3.6 Accident and other costs

After the maintenance section of the evaluation is complete, the 'accident and other costs' box will be ticked automatically. The reduction in road length has provided savings in accident costs. Accident costs in the first year of the base case are estimated at $295 000 while the project case accident costs are only $271 000, see Figure 84.

Figure 84: Realignment accident costs



Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total ($'000)
Accident	271	282	293	305	317	330	343	357	371	17,000
Emission	0	0	0	0	0	0	0	0	0	0
Environment	0	0	0	0	0	0	0	0	0	0
Secondary	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Annual Total Costs	271	282	293	305	317	330	343	357	371	17,000
Disc Annual Total Costs	256	251	246	242	237	233	228	224	220	6,187

5.3.7 Results and decision criteria

In this example, the intention of the proposed project is to realign a poorly designed section of road. The new road will provide a safer, higher speed environment for road users. The project has a discounted cost of $6.9 million at the 6 % discount rate, see Figure 85. There are some minor savings in maintenance costs due to the delay in periodic maintenance costs. The majority of project benefits comprise savings in VOC for road users. As expected the realignment provides a new route that reduces fuel consumption and improves vehicle performance. The NPV for the project is over $12.6 million at the discount rate of 6%. The BCR for this realignment project is 2.82 at a discount rate of 6% suggesting that this initiative is economically viable.

Figure 85: Realignment CBA results

Results - Decision Criteria Recalc No 6

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	7,196,556	6,964,350	6,856,396	6,752,659	6,555,475
Discounted Capital Costs	7,470,414	7,226,771	7,109,791	6,995,885	6,776,860
Discounted Other Costs	-273,859	-262,421	-253,396	-243,225	-221,384
Discounted Benefits	26,901,235	19,662,026	17,013,618	14,833,890	11,517,742
Private TTC Savings	5,755,645	4,293,204	3,750,416	3,299,524	2,604,374
Commercial TTC Savings	3,048,564	2,259,988	1,968,218	1,726,359	1,354,675
Private VOC Savings	11,668,930	8,438,145	7,264,435	6,302,847	4,849,660
Commercial VOC Savings	5,748,015	4,176,745	3,604,456	3,134,773	2,423,080
Discounted Accident Savings	680,080	493,944	426,093	370,387	285,952
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	19,704,679	12,697,676	10,157,222	8,081,230	4,962,267
Net Present Value per dollar Investment	2.64	1.76	1.43	1.16	0.73
Benefit Cost Ratio Excl. Private Time	2.94	2.21	1.93	1.71	1.36
Benefit Cost Ratio	3.74	2.82	2.48	2.20	1.76
First Year Rate of Return	12.11%	11.83%	11.69%	11.55%	11.29%

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5.4 Overtaking lane

Overtaking lanes are usually built where the terrain and geometry of a road causes slow vehicles to impede the general flow of traffic. Overtaking lanes can range in length from several hundred metres to several kilometres. Figure 86 shows a side-by-side overtaking lane.

Figure 86: Overtaking lane

The evaluation of overtaking lane projects differs from other projects as special methods apply to the calculation of benefits.

1. Capacity is improved along the length of the overtaking lane. Increased capacity at a given AADT allows higher speeds (reduced travel time) and a lower accident risk. The construction of the overtaking lane reduces the accident rate at this site by 25%.

2. The provision of a passing lane has a 'downstream' effect on traffic. Overtaking lanes cause a dispersion of the traffic platoons that accumulate behind slow vehicles. Depending on the distance between overtaking lanes and their length, they have the effect of increasing the capacity of the road section immediately following the end of the passing lanes. Because the slow vehicles are now at the end of the platoon, other vehicles can travel more quickly along this downstream section. These vehicles experience user cost reductions along the downstream section, and the risk of accidents is further reduced as the need for overtaking is reduced.

3. The upstream road section or the road section leading up to the overtaking lane will experience a reduction in the accident rate of 2.5%. The assumption is that road users will be aware of the overtaking lane ahead and will delay overtaking.

CBA6 contains default factors for the estimation of downstream benefits:

- length of downstream area: 5 km
- capacity increase in downstream area: 20%
- accident reduction in downstream area: 2.5%
- length of upstream area: 3 km
- accident reduction in the upstream area: 2.5%.

System users are able to change the default capacity increase in the downstream area if there is sufficient site-specific data to support this change, see Section 2.6.3.

For more information on the calculation of overtaking lane benefits see Section 2.4.5 of the *Theoretical Guide* and Section 8.4 of the *Technical Guide*.

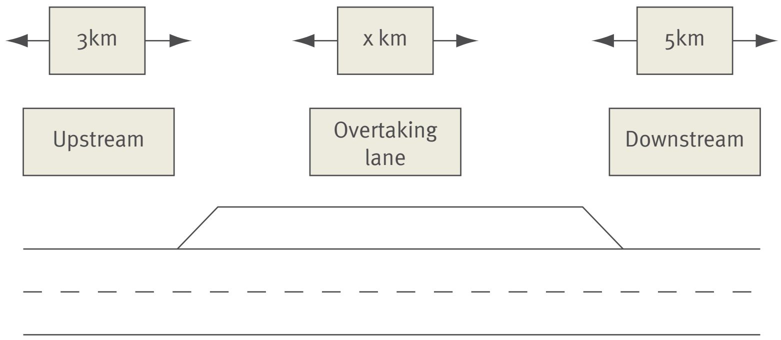
CBA6 has three overtaking modules: single, head-to-head and side-by-side. The remainder of Section 5.4 will provide case studies for each type of overtaking lane.

5.4.1 Single overtaking lane

A single overtaking lane currently provides for overtaking in one direction only. The single overtaking lane directs slow moving traffic to the left-hand lane, while faster vehicles overtake via the right-hand lane. For a single overtaking lane, there is only one upstream and downstream area.

Note: Sections 5.4.2 and 5.4.3 give examples of two adjoining overtaking lanes which provide overtaking opportunities in both directions.

Figure 87: Single overtaking lane



5.4.1.1 Single overtaking lane case study

A TMR example is used as a basis for this case study. TMR's Northern Region has proposed a 2 km overtaking lane be built on the Bruce Highway between Emmett Creek and Mackenzie Creek. The project's main objective is to improve travel times and safety on this section of the Bruce Highway.

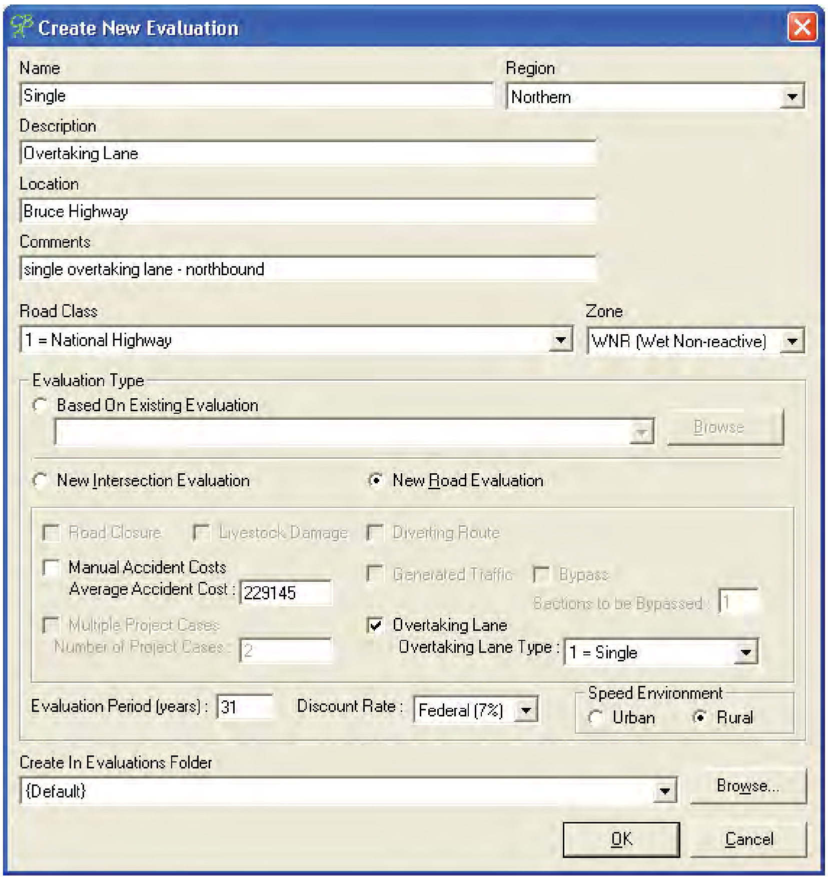
The base case is defined as the existing 2 km section consisting of a two-lane undivided seal of MRS 12. Traffic levels on this part of the highway remain reasonably stable at around 4545 AADT and grow at around 2% per annum. The base case includes routine maintenance costs on the existing two-lane highway for the life of the project evaluation period, and some periodic maintenance in Year 7 with subsequent spending every five years.

The project case will involve the construction of a single overtaking lane in the northbound direction of the highway. The timing of maintenance activity in the project case will be the same as the base case, but maintenance costs will be around 50% higher.

5.4.1.2 Create new evaluation

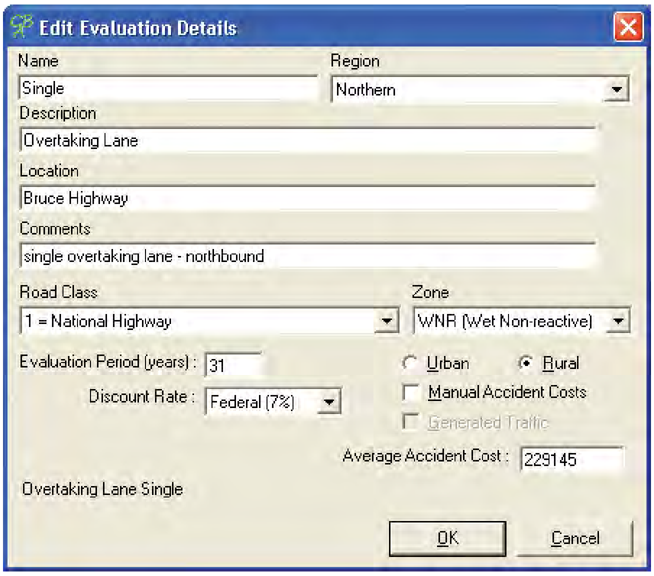
Create a new evaluation as shown in Section 3.1 and previous case studies. For an overtaking lane project, tick the 'overtaking lane' box from the list of advanced modules. Select option 1 (1=single) from the overtaking lane drop-down menu, see Figure 88.

Figure 88: Create new single overtaking lane evaluation



Note: The 'edit evalaution' screen for a single overtaking lane is shown in Figure 89. The overtaking lane type is shown in the bottom left-hand corner.

Figure 89: Single overtaking lane edit evaluation screen

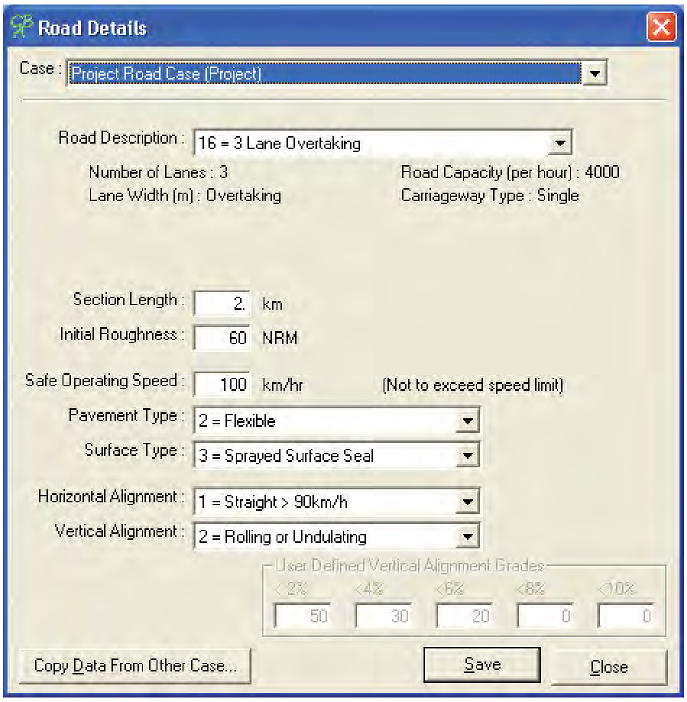


5.4.1.3 Road details

The 'road details' screen for an overtaking lane is similar to previous case studies. For the base case the section length is 2 km, initial roughness 80 NRM, speed 100 km/h, pavement type is flexible and there is a sprayed surface seal. In the base case the horizontal alignment is straight and there is a rolling vertical alignment. The project case details are shown in Figure 90.

Note: The only available option for the project case road description is MRS 16: 3 lane overtaking.

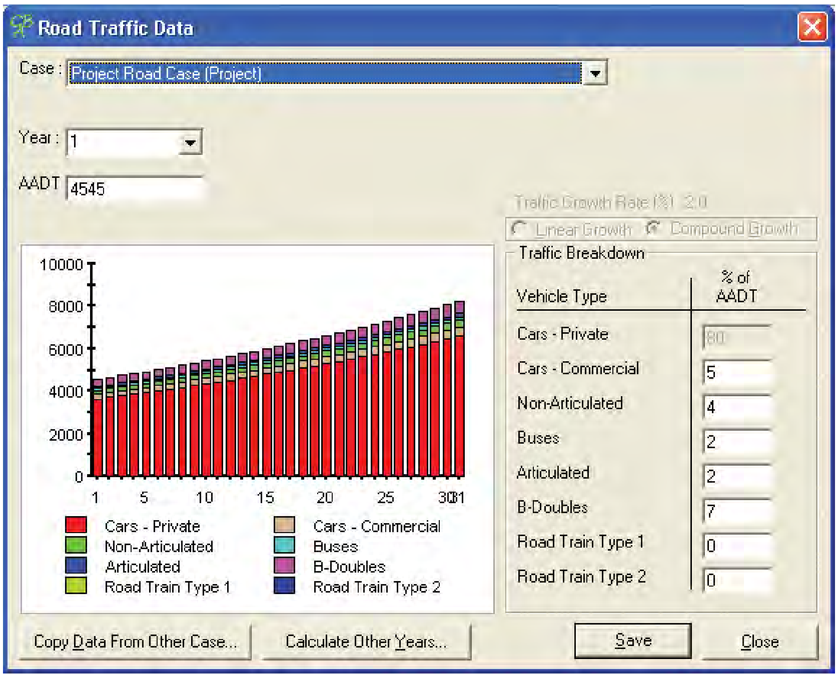
Figure 90: Single overtaking lane project



5.4.1.4 Road traffic data

The road traffic data is the same for the base case and the project case, see Figure 91. The AADT is 4545 in Year 1; the growth rate is 2% compound per annum. Traffic breakdown is 80% private cars, 5% commercial cars, 4% non-articulated, 2% buses, 2% articulated, 7% B-doubles, 0% road train type 1 and 0% road train type 2.

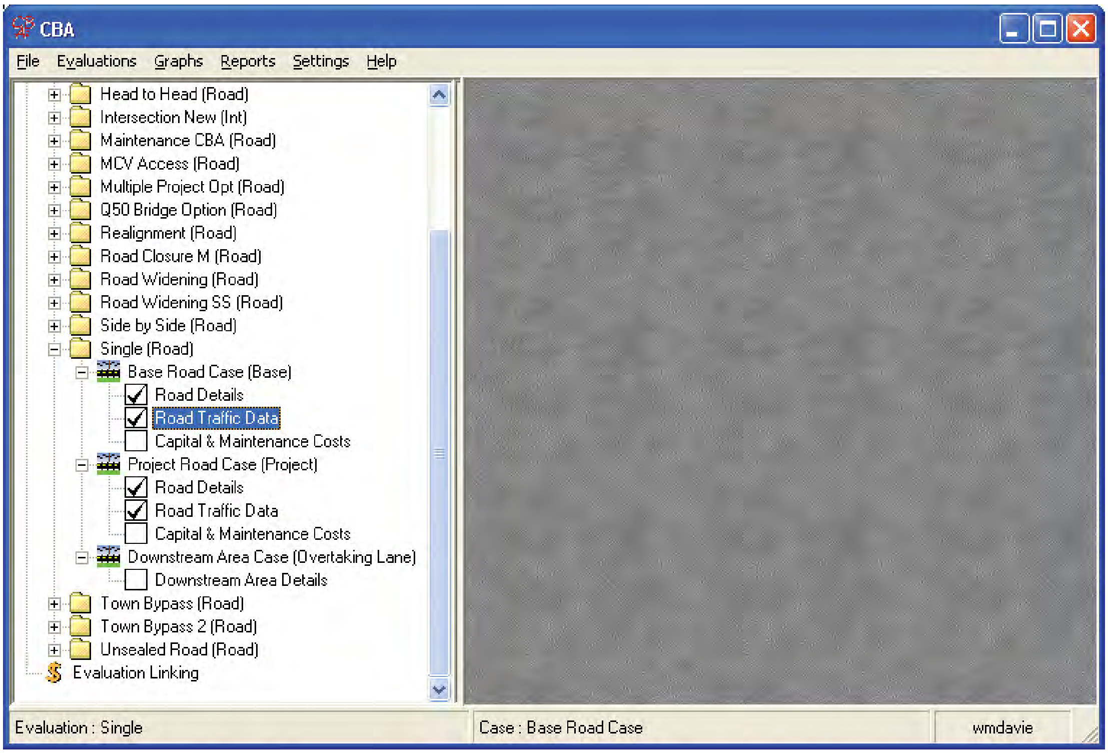
Figure 91: Single overtaking lane traffic data



5.4.1.5 Downstream area

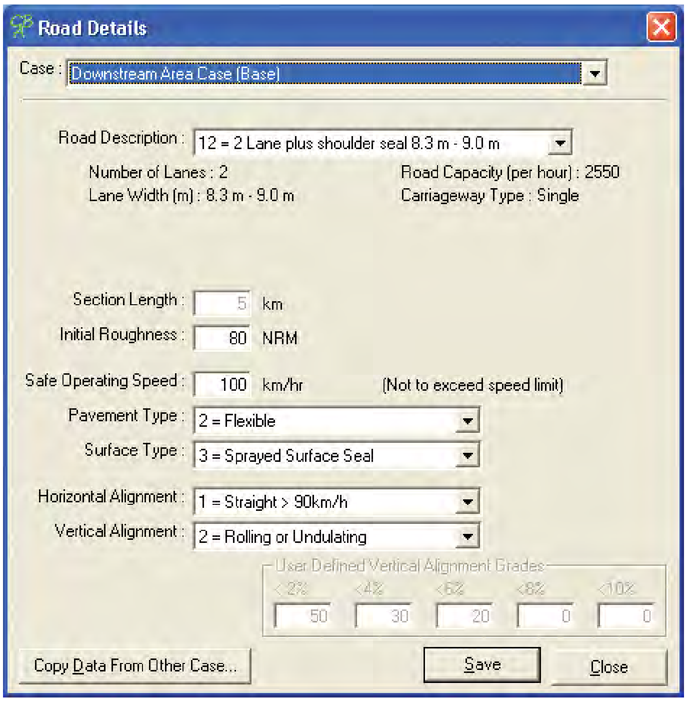
After the road traffic data has been entered for the base and project cases, a new drop-down option will appear for the ‘downstream area case’, see Figure 91. The downstream area in CBA6 refers to the area immediately after the overtaking lane, see Figure 92.

Figure 92: Single overtaking lane downstream area workspace



The downstream area case defines the road details for the highway immediately after the overtaking lane ends. System users will note that the section length has been defaulted to 5 km, see Figure 93. In this example the downstream area is assumed to have the same properties as the base case, however the downstream area has increased capacity of 20% over the base case road configuration. See Section 8.4.1 of the *Technical Guide* for further details on capacity increase. Use the 'copy data from other case' button to transfer the base case road details to the downstream area.

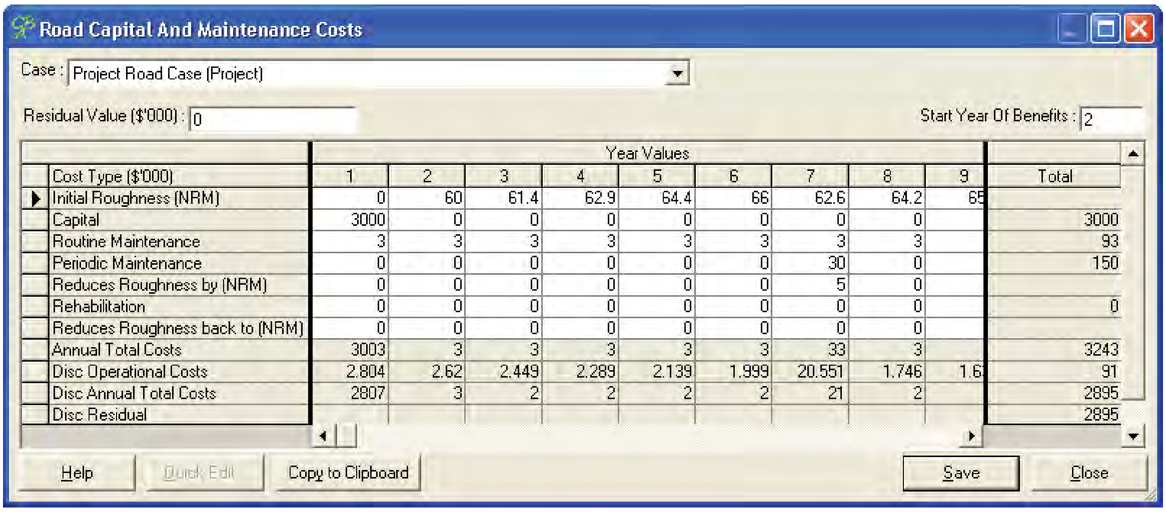
Figure 93: Downstream area for single overtaking lane



5.4.1.6 Capital and maintenance costs

Costs for the base and project cases can be found in Appendix A. As shown in Figure 94, the capital costs are \$3 million in Year 1.

Figure 94: Single overtaking lane costs

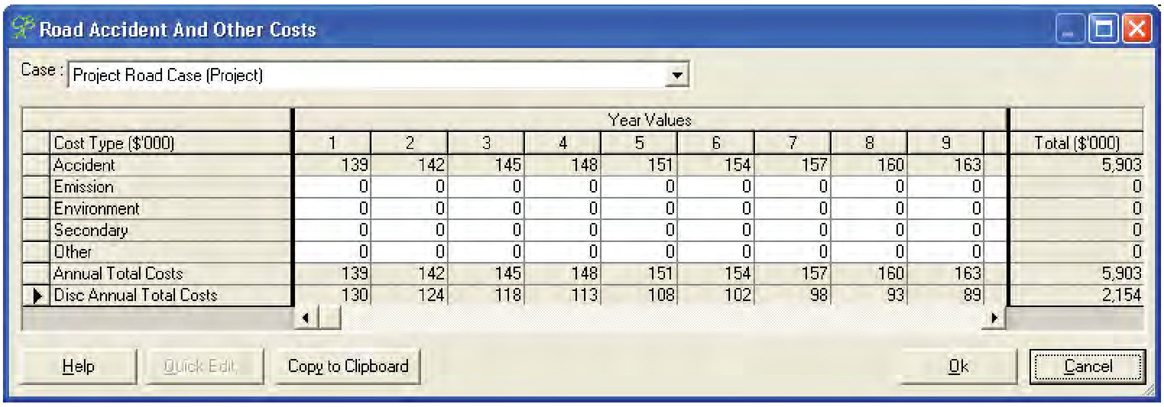


	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	60	61.4	62.9	64.4	66	62.6	64.2	65	
Capital	3000	0	0	0	0	0	0	0		3000
Routine Maintenance	3	3	3	3	3	3	3	3		93
Periodic Maintenance	0	0	0	0	0	0	30	0		150
Reduces Roughness by (NRM)	0	0	0	0	0	0	5	0		
Rehabilitation	0	0	0	0	0	0	0	0		0
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	3003	3	3	3	3	3	33	3		3243
Disc Operational Costs	2.804	2.62	2.449	2.289	2.139	1.999	20.551	1.746	1.6	91
Disc Annual Total Costs	2807	3	2	2	2	2	21	2		2895
Disc Residual										2895

5.4.1.7 Accident and other costs

The provision of overtaking lanes provides a number of safety benefits. CBA6 assumes that there will be a 25% reduction in the frequency of accidents on the overtaking lane section.

Figure 95: Single overtaking lane accident costs



	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total ($'000)
Accident	139	142	145	148	151	154	157	160	163	5,903
Emission	0	0	0	0	0	0	0	0	0	0
Environment	0	0	0	0	0	0	0	0	0	0
Secondary	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Annual Total Costs	139	142	145	148	151	154	157	160	163	5,903
Disc Annual Total Costs	130	124	118	113	108	102	98	93	89	2,154

5.4.1.8 Results and decision criteria

The project has a total discounted cost of $2.8 million at the 7% discount rate. There are some minor increases in maintenance costs to cater for the overtaking lane. The majority of project benefits are savings in TTC and accident costs. As expected, the overtaking lane saved motorists over $1.3 million in TTC and $500 000 in accident costs. This satisfies our objective to provide a safer road for vehicles to pass slower traffic. System users should note that private VOC benefits are negative at some discount rates. This is due to the increase in operating speed that is achieved from the increased capacity of the overtaking lane which subsequently increases fuel consumption. The impact of roughness on VOC benefits in later years is further reduced with higher discount rates. See Section 4.1 of the *Technical Guide* for further information on fuel consumption.

The NPV for this project is over $600 000 at the discount rate of 7%. The BCR for the single overtaking lane is 1.21 at the discount rate of 7%.

Figure 96: Single overtaking lane results

Results - Decision Criteria Recalc No 2

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	2,928,870	2,864,300	2,833,970	2,804,728	2,749,039
Discounted Capital Costs	2,884,615	2,830,189	2,803,738	2,777,778	2,727,273
Discounted Other Costs	44,255	34,112	30,232	26,950	21,767
Discounted Benefits	5,476,662	3,983,516	3,439,232	2,992,614	2,316,658
Private TTC Savings	2,184,866	1,598,959	1,384,692	1,208,493	940,951
Commercial TTC Savings	678,733	467,240	392,290	331,960	243,281
Private VOC Savings	91,830	34,356	15,555	1,329	-17,435
Commercial VOC Savings	897,200	647,611	556,933	482,691	370,706
Discounted Accident Savings	1,624,033	1,235,351	1,089,763	968,141	779,154
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	2,547,791	1,119,216	605,262	187,886	-432,381
Net Present Value per dollar Investment	0.88	0.40	0.22	0.07	-0.16
Benefit Cost Ratio Excl. Private Time	1.12	0.83	0.72	0.64	0.50
Benefit Cost Ratio	1.87	1.39	1.21	1.07	0.84
First Year Rate of Return	5.50%	5.39%	5.34%	5.29%	5.20%

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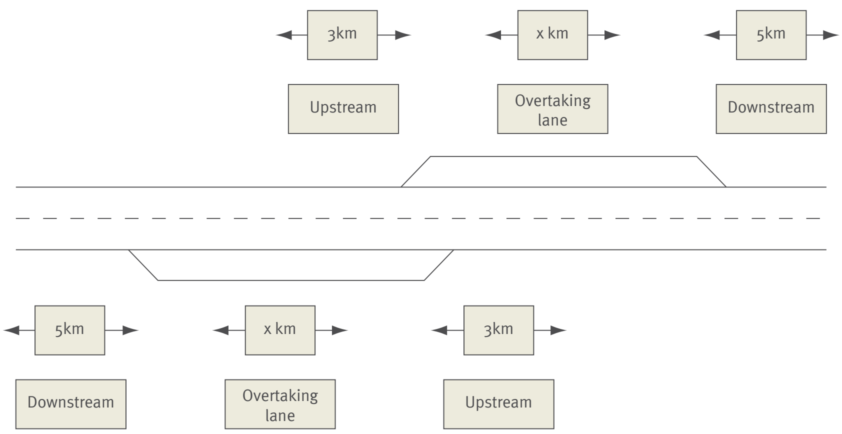
5.4.2 Head-to-head overtaking lane

A head-to-head overtaking lane configuration provides a passing lane in each direction. The passing lanes will be located so that they are not adjacent to each other. While the single overtaking lane caters for traffic in one direction, the head-to-head overtaking lane will provide passing opportunities on both sides of the road, see Figure 97.

Figure 97: head-to-head overtaking lane scaled



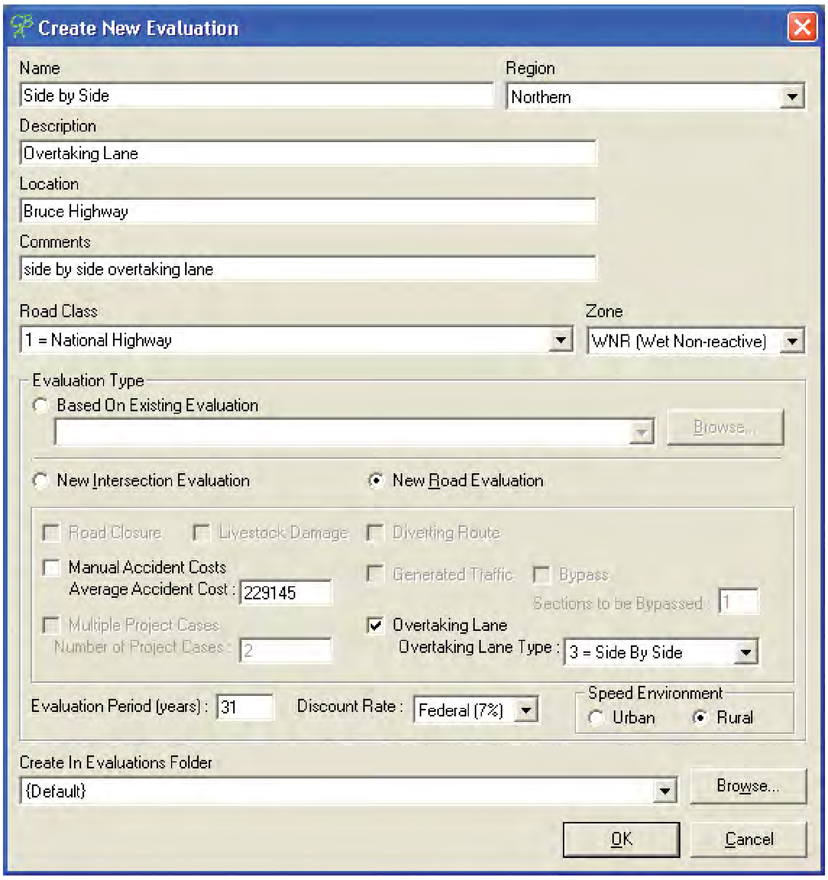
5.4.2.1 Head-to-head overtaking lane case study

This case study will build on the case study from Section 5.4.1.1. Assume that the region is proposing two separate overtaking lanes, one in each direction, on the Bruce Highway between Emmett Creek and Mackenzie Creek. The proposed upgrade of the site incorporates a total area of 4 km. All other data will remain the same (see Appendix A for further data inputs).

5.4.2.1.1. Create new evaluation

For an overtaking lane project, tick the 'overtaking lane' box from the list of advanced modules. From the overtaking lane drop-down menu select option 2 head-to-head, see Figure 98.

Figure 98: Head-to-head evaluation



Note: The 'edit evaluation' screen for the head-to-head overtaking lane is shown in Figure 99. The overtaking lane type is shown in the bottom left hand corner.

Figure 99: Head-to-head overtaking lane edit evaluation screen

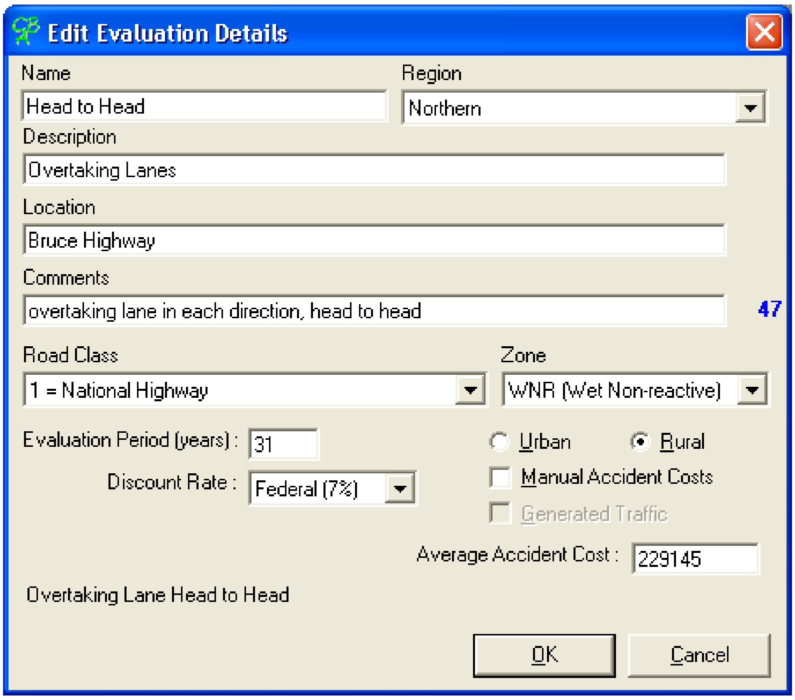
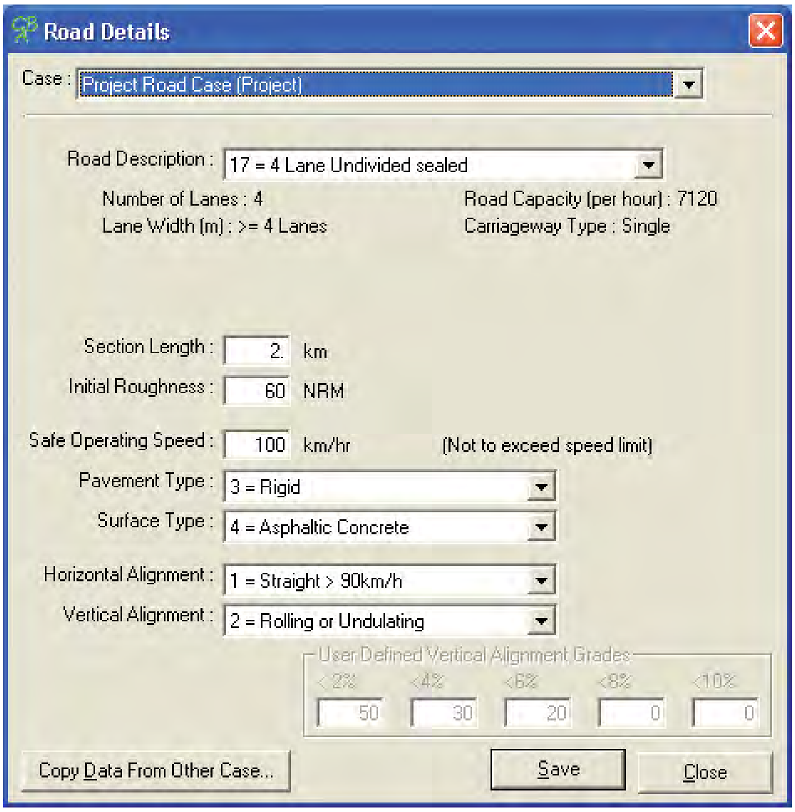


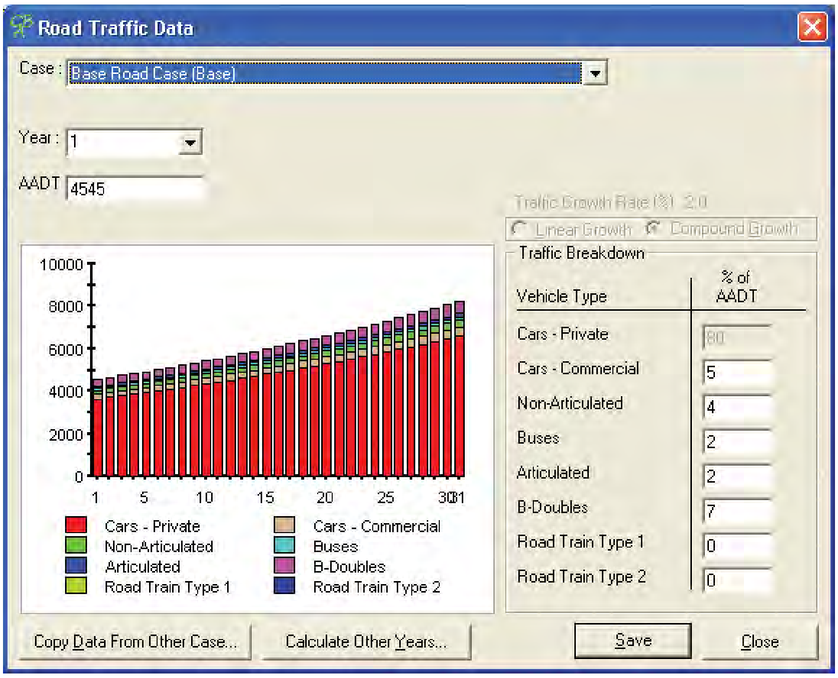
Figure 100: Head-to-head road details



5.4.2.2 Road details

The 'road details' screen for a head-to-head overtaking lane remains similar to previous case studies. The section length needs to be altered to 4 km, see Figure 100. The project case MRS will be 16, as pavement improvement works will be undertaken together with the construction of the overtaking lanes. Initial roughness in the project case will be 60 NRM.

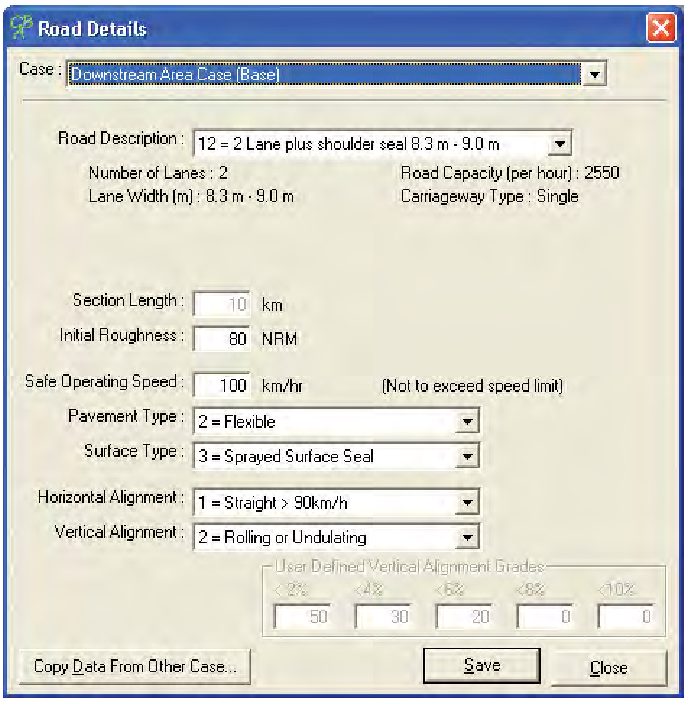
Figure 101: Head to head traffic data



5.4.2.3 Road traffic data

Road traffic data inputs are the same for the base case and the project case. The AADT is 4545 in Year 1; the growth rate is 2% and compound, see Figure 101.

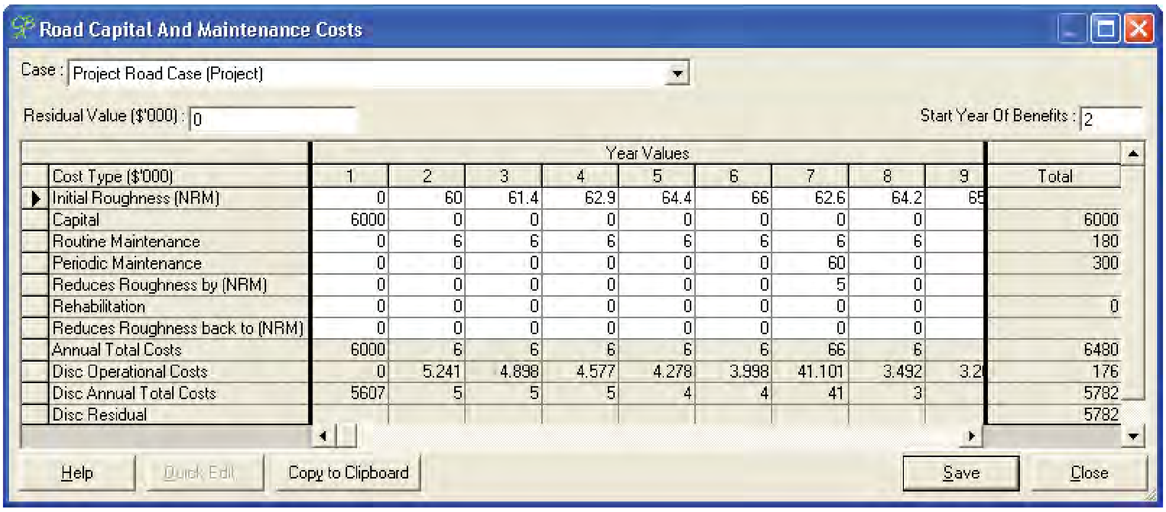
Figure 102: Head-to-head downstream area



5.4.2.4 Downstream area

The downstream area case defines the road details for the highway immediately after the overtaking lane ends. The section length has now been defaulted to 10 km as there are effectively two downstream areas (immediately following the northbound overtaking lane and immediately following the southbound overtaking lane), see Figure 102.

Figure 103: Head-to-head overtaking lane costs


Road Capital And Maintenance Costs

Case : Project Road Case (Project)

Residual Value ($'000) : 0 Start Year Of Benefits : 2

	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	60	61.4	62.9	64.4	66	62.6	64.2	65	
Capital	6000	0	0	0	0	0	0	0		6000
Routine Maintenance	0	6	6	6	6	6	6	6		180
Periodic Maintenance	0	0	0	0	0	0	60	0		300
Reduces Roughness by (NRM)	0	0	0	0	0	0	5	0		
Rehabilitation	0	0	0	0	0	0	0	0		0
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	6000	6	6	6	6	6	66	6		6480
Disc Operational Costs	0	5.241	4.898	4.577	4.278	3.998	41.101	3.492	3.2	176
Disc Annual Total Costs	5607	5	5	5	4	4	41	3		5782
Disc Residual										5782

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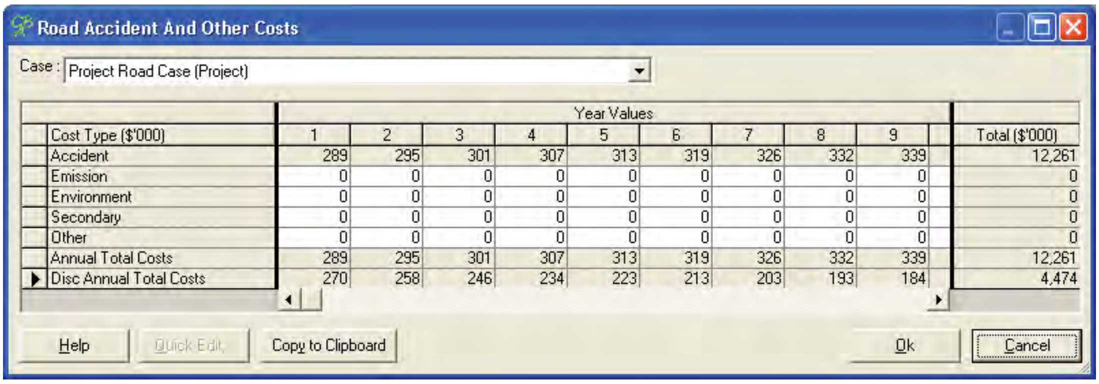
5.4.2.5 Capital and maintenance costs

Cost data for the base and project cases can be found in Appendix A. Project capital costs are now $6 million in Year 1 to allow for the construction of an additional overtaking lane in the southbound direction, see Figure 103.

Figure 104: Head-to-head accident costs


Road Accident And Other Costs

Case : Project Road Case (Project)

	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total ($'000)
Accident	289	295	301	307	313	319	326	332	339	12,261
Emission	0	0	0	0	0	0	0	0	0	0
Environment	0	0	0	0	0	0	0	0	0	0
Secondary	0	0	0	0	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	0	0	0
Annual Total Costs	289	295	301	307	313	319	326	332	339	12,261
Disc Annual Total Costs	270	258	246	234	223	213	203	193	184	4,474

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5.4.2.6 Accident and other costs

The head-to-head overtaking lane provides a significant reduction in accident frequency compared to the base case. Accident costs for the head-to-head overtaking lane are shown in Figure 103. See Section 8.4.2.2 of the *Technical Guide* for detailed information on head-to-head overtaking lane accident cost savings. It is useful to compare the accident cost savings of the head-to-head overtaking lane to the single overtaking lane shown in the previous case study (compare discounted accident cost savings of Figure 94 to Figure 104).

Figure 105: Head-to-head overtaking lane results

Results - Decision Criteria Recalc No 5

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	5,851,972	5,722,940	5,662,332	5,603,900	5,492,624
Discounted Capital Costs	5,769,231	5,660,377	5,607,477	5,555,556	5,454,545
Discounted Other Costs	82,741	62,563	54,856	48,344	38,079
Discounted Benefits	10,721,320	7,790,555	6,722,784	5,846,923	4,522,009
Private TTC Savings	4,369,731	3,197,917	2,769,383	2,416,986	1,881,902
Commercial TTC Savings	1,357,466	934,480	784,579	663,919	486,563
Private VOC Savings	183,661	68,712	31,110	2,658	-34,869
Commercial VOC Savings	1,794,400	1,295,222	1,113,866	965,383	741,413
Discounted Accident Savings	3,016,061	2,294,223	2,023,846	1,797,977	1,447,001
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	4,869,348	2,067,614	1,060,452	243,023	-970,615
Net Present Value per dollar Investment	0.84	0.37	0.19	0.04	-0.18
Benefit Cost Ratio Excl. Private Time	1.09	0.80	0.70	0.61	0.48
Benefit Cost Ratio	1.83	1.36	1.19	1.04	0.82
First Year Rate of Return	5.32%	5.22%	5.17%	5.12%	5.03%

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5.4.2.7 Results and decision criteria

In this example the proposed head-to-head overtaking lane should provide a safe passing opportunity for road users travelling in both directions on the Bruce Highway. Results for the head-to-head overtaking lane are shown in Figure 105.

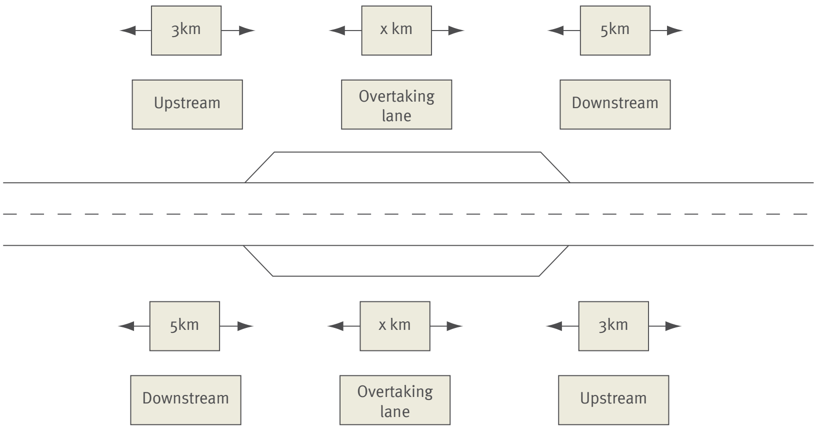
The project has a total discounted cost of $5.6 million at the 7% discount rate. There are some minor increases in maintenance costs to cater for two overtaking lanes. The majority of project benefits are achieved through TTC savings and accident cost savings. As expected, the two overtaking lanes saved motorists over $3.4 million in TTC and $2 million in accident costs. This satisfies our objective to provide a safer road for vehicles to pass slower traffic on the Bruce Highway.

The NPV for the project is over $1 million at a discount rate of 7%. This is a significant increase over the NPV achieved for the preceding single overtaking lane example. If the cost per overtaking lane is kept constant (i.e. $3 million), the head-to-head overtaking lane should have a higher NPV than a single overtaking lane due to the increase in overtaking opportunities in both directions accompanied by the increase in downstream benefits. If the incremental increase in cost for an additional overtaking lane is above that of a single overtaking lane, the additional overtaking lane may not be viable.

5.4.3 Side-by-side overtaking lane

An alternative overtaking lane design to those presented in the previous two case studies is the side-by-side overtaking lane. A side-by-side design provides a passing lane in each direction and locates the lanes adjacent to each other. A side-by-side overtaking lane is essentially a duplication of the two existing lanes. Although a side-by-side overtaking lane and a duplication are similar, there are key design differences for the purpose of conducting an evaluation using CBA6.

Figure 106: Side-by-side overtaking lane



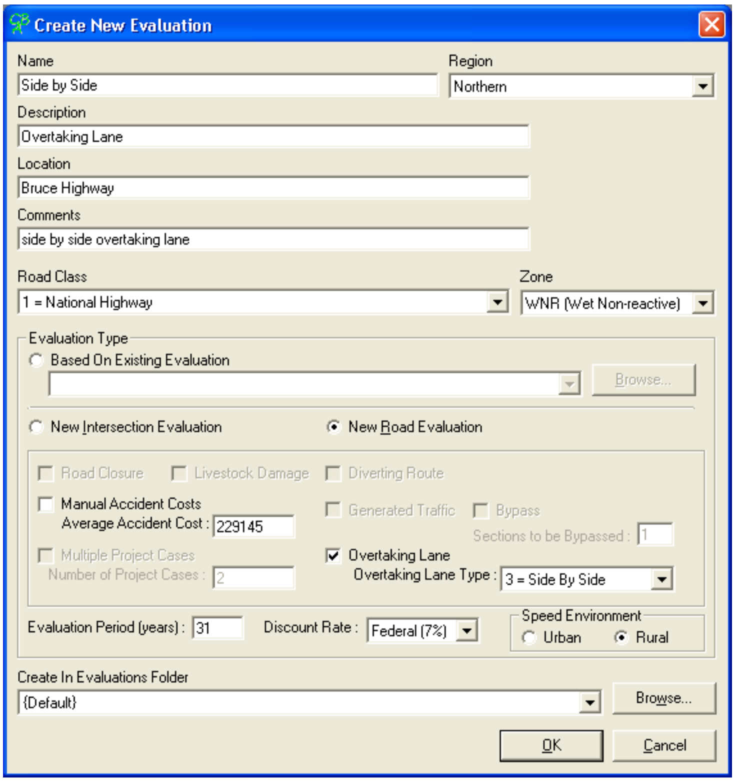
5.4.3.1 Side-by-side overtaking lane case study

This case study proposes a side-by-side overtaking lane as an alternative to the single overtaking lane from Section 5.4.1.1 or the head-to-head overtaking lane from Section 5.4.2.1. The project involves constructing a 2 km side-by-side overtaking lane on the Bruce Highway between Emmett Creek and Mackenzie Creek.

5.4.3.2 Create new evaluation

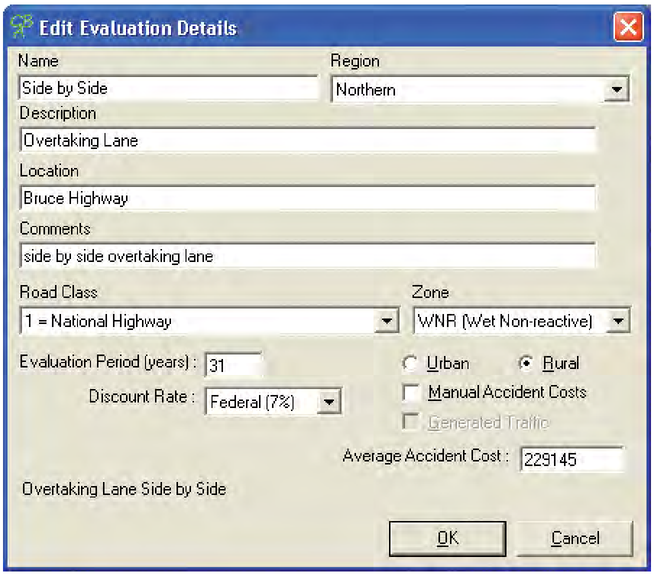
Create a new evaluation as per previous case studies. For an overtaking lane project tick the ‘overtaking lane’ box from the list of advanced modules. From the overtaking lane drop-down menu select option 3 side-by-side, see Figure 107.

Figure 107: Side-by-side overtaking lane evaluation



Note: The ‘edit evalaution’ screen for the side-by-side overtaking lane is shown in Figure 108. The overtaking lane type is shown in the bottom left hand corner.

Figure 108: Side-by-side overtaking lane edit evaluation screen

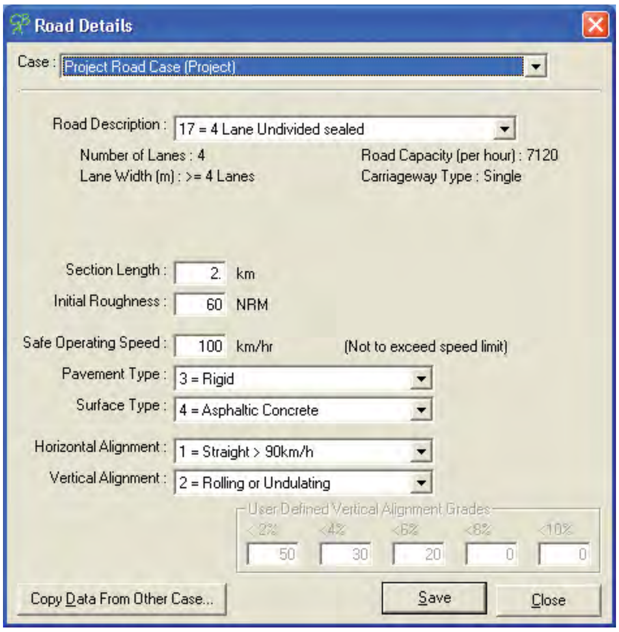


5.4.3.3 Road details

The road details screen for a side-by-side overtaking lane is similar to the previous case studies. However, the only available option for the project case road description is MRS 17, four-lane undivided seal, see Figure 109. The default pavement type and surface type for MRS 17 have been adopted. The system user should change these inputs whenever appropriate.

Note: For the side-by-side evaluation, the section length is specified at 2 km whereas the section length for the head-to-head overtaking lane was 4 km.

Figure 109: Side-by-side overtaking lane road details



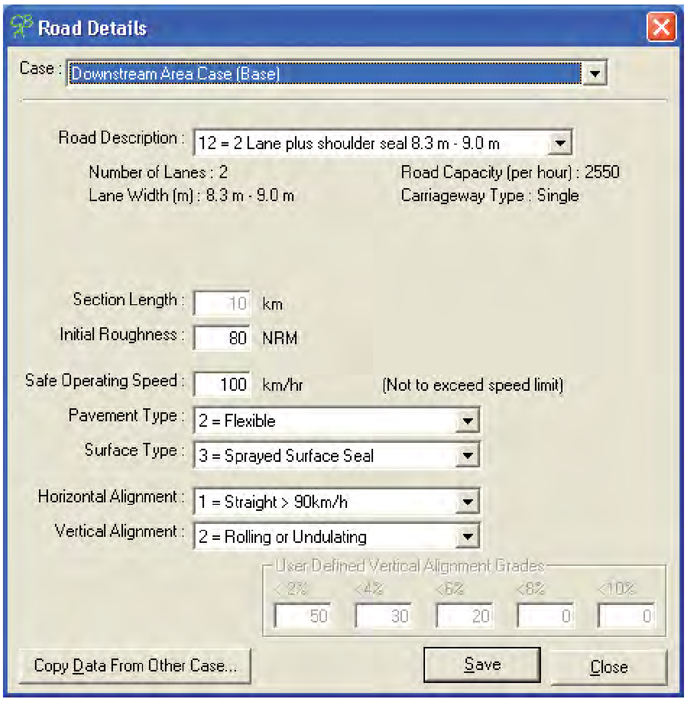
5.4.3.4 Road traffic data

The road traffic data inputs are the same for the base case and the project case. The AADT is 4545 in Year 1; the growth rate is 2% and compound. This is the same input data as the previous overtaking lane case studies, see Figure 101.

5.4.3.5 Downstream area

After the road traffic data has been entered for the base case and project case, a new drop-down option will appear for the 'downstream area case'. System users will note that the section length has now been defaulted to 10 km to account for two downstream areas. Use the 'copy data from other case' button to transfer the base case road details to the downstream area. Before doing this, system users should check input data. For simplicity, the downstream area in both directions is assumed to have the same road characteristics, see Figure 110.

Figure 110: Head to head downstream area



5.4.3.6 Capital and maintenance costs

Cost data for the base and project cases can be found in Appendix A. Project capital costs are now $5.5 million in Year 1 to take into account costs on the side-by-side overtaking lanes. As the two overtaking lanes will be co-located, it will be assumed that costs will be lower compared to the costs of a head-to-head project.

5.4.3.7 Accident and other costs

The side-by-side overtaking lane will provide a number of safety benefits. See Section 8.4.2.3 of the *Technical Guide* for further information on the reduction in accidents for side-by-side overtaking lanes.

5.4.3.8 Results and decision criteria

In this example a side-by-side overtaking lane is proposed as an alternative to a head-to-head overtaking lane. Figure 111 presents the CBA results of the side-by-side overtaking lane. The BCR for this overtaking lane option is 0.98 which implies that the side-by-side overtaking lanes are not viable.

Figure 111: Side by side overtaking lane results

Results - Decision Criteria Recalc No 6

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	5,371,202	5,251,242	5,195,043	5,140,937	5,038,079
Discounted Capital Costs	5,288,462	5,188,679	5,140,187	5,092,593	5,000,000
Discounted Other Costs	82,741	62,563	54,856	48,344	38,079
Discounted Benefits	8,036,747	5,888,963	5,102,570	4,455,397	3,471,669
Private TTC Savings	3,199,025	2,335,015	2,019,303	1,759,843	1,366,275
Commercial TTC Savings	1,108,677	794,275	680,577	587,785	448,490
Private VOC Savings	364,137	241,607	198,455	163,896	113,556
Commercial VOC Savings	1,276,866	929,758	803,110	699,120	541,578
Discounted Accident Savings	2,088,042	1,588,308	1,401,124	1,244,753	1,001,770
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	2,665,544	637,721	-92,473	-685,540	-1,566,410
Net Present Value per dollar Investment	0.50	0.12	-0.02	-0.13	-0.31
Benefit Cost Ratio Excl. Private Time	0.90	0.68	0.59	0.52	0.42
Benefit Cost Ratio	1.50	1.12	0.98	0.87	0.69
First Year Rate of Return	4.61%	4.53%	4.49%	4.44%	4.36%

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5.5 Road closure

The road closure module within CBA6 is relatively complex and requires the system user to collect a wide range of inputs before conducting a road project evaluation. System users will require detailed information on the project site and some understanding of traffic conditions in the immediate area of a project. CBA6 has two separate road closure modules: road closure (with diversion) and road closure. This manual uses the example of a flood immunity project to illustrate the module in CBA6. A road closure can be any type of closure.

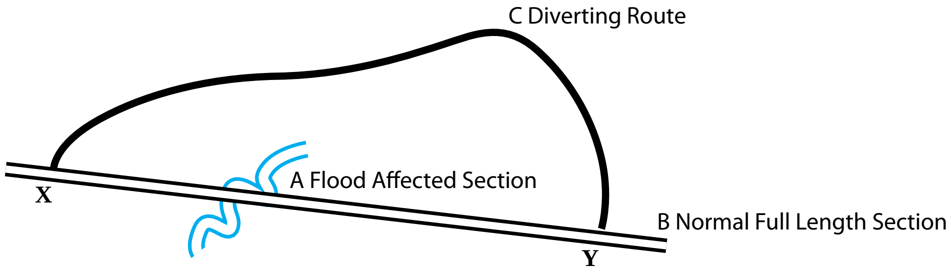
5.5.1 Road closure (with diversion)

CBA6 can be used to evaluate flood improvement projects. Flood immunity projects require a detailed understanding of both the road network and road user behaviour. Road user responses to flooding can be quite variable depending on the frequency, severity and extent of flooding. Flood warning times and the availability of alternative routes will also affect the decisions made by road users. The following three options exist for road users affected by flooded roads:

- Wait – remain at the flood site for waters to subside.
- Divert – use an alternative route around the flood affected area.
- Do not travel – choose not to travel at all.

For all road closure projects CBA6 requires information and data on the average annual time of closure (AATOC) and the average duration of closure (ADC) for the base and project cases.

Before undertaking a flood immunity improvement project the system user should have sufficient knowledge of the following:



- flood area – frequency of flooding from historical evidence, at least 10 years
- travel demand – road users response to a closed road, number of vehicles that will wait, divert or choose not to travel
- diversion route – the road network and suitable alternative routes for road users
- network inundation – other affected roads.

Note: While this section highlights roads closed due to flooding, the same information and theory applies to other causes of road closures. These could include rock falls or land slippages.

5.5.1.1 Flood immunity improvement case study

This case study involves a bridge that is consistently inundated.

Table 3 shows the flood history for the project site. Based on information from the last 20 years there have been five flooding events where the ADC was 56 hours. The subsequent AATOC for the road over the last 20 years is 14 hours.

Table 3: Base case flooding history

Base case flooding																				
Years	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Number of floods	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0
Total time closed (hours)	60	0	0	0	0	0	0	68	0	0	48	0	0	24	0	0	0	0	80	0
																			AATOC	14
																			ADC	56

From Figure 111, road users that choose to divert during road closures must travel an additional 40 km along Section C compared with the normal length of the road from Section X to Section Y.

TMR now proposes a Q100 standard bridge be built on the project site. Section A from Figure 112 is the 1 km flood affected section to be upgraded. All other input data for this case study is shown in Appendix A.

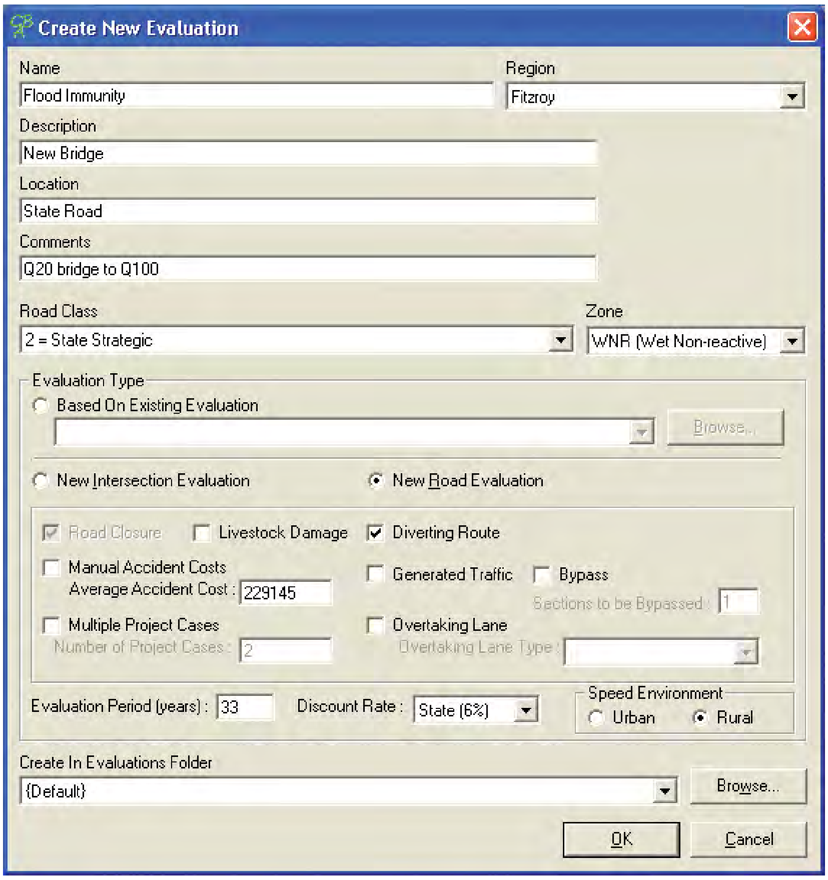
The appropriate sequence of data entry into CBA6 for road closure evaluations has been outlined in Section 5.5.1.2.

Figure 112: Flood and diversion route

5.5.1.2 Create new evaluation

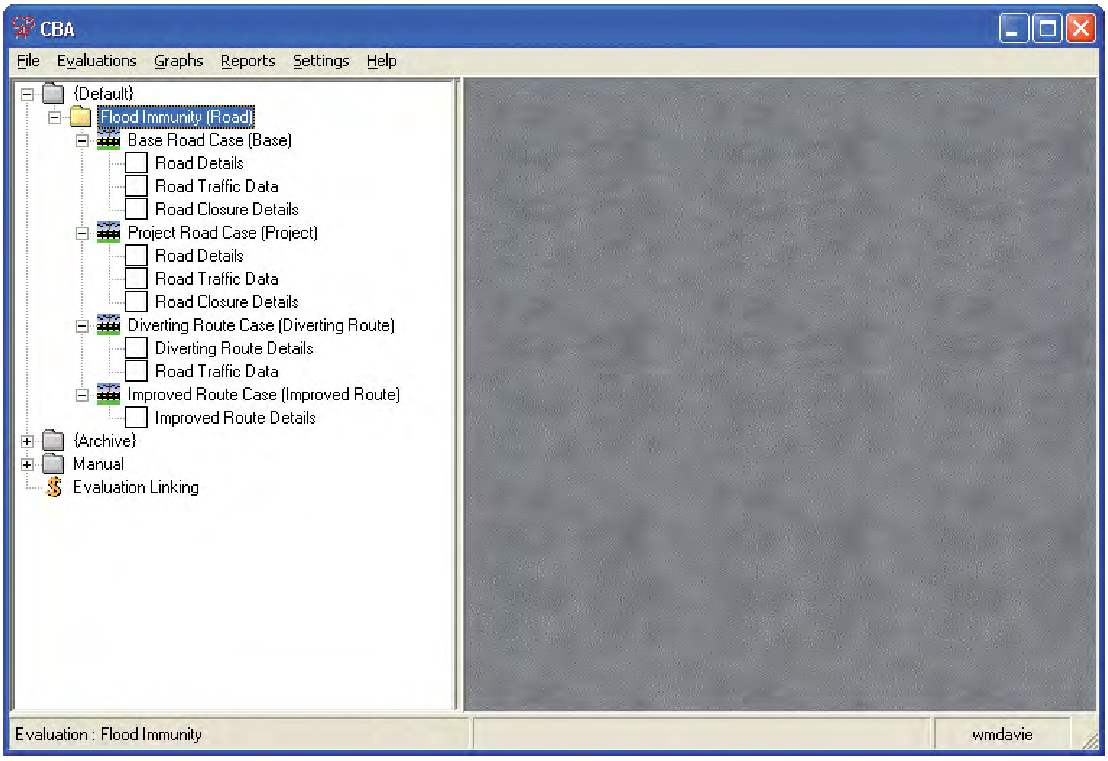
To create a flood immunity improvement project using CBA6, the system user must ensure the ‘road closure’ and ‘diverting route’ boxes are ticked, see Figure 113. Selecting the ‘diverting route’ box will automatically tick the ‘road closure’ option.

Figure 113: Flood immunity new evaluation screen



After the flood immunity improvement project has been initially created in CBA6, there are a number of new input fields the system user is required to complete. From Figure 114, the new inputs include road closure details, diverting route case and the improved route case (input of data in CBA6 should follow the sequence of sections below).

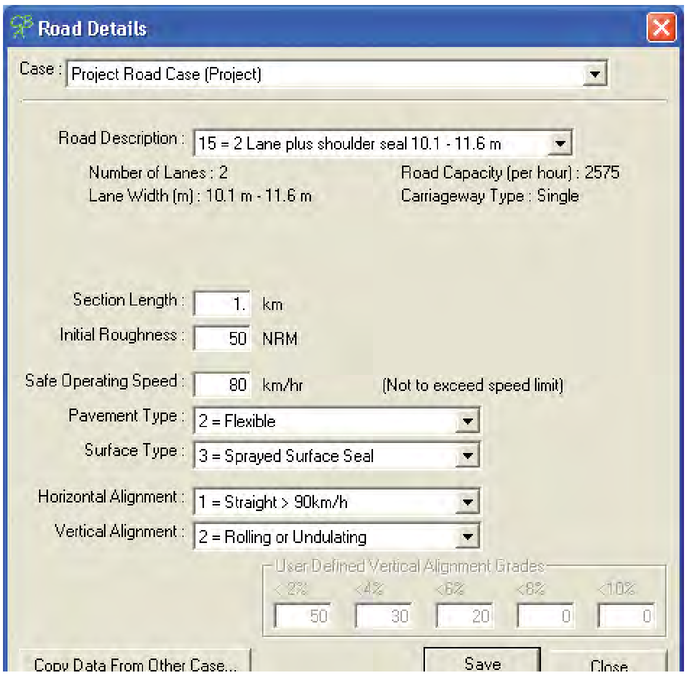
Figure 114: Flood immunity workspace



5.5.1.3 Road details

The current 1 km section in the base case has an MRS of 10. The project case will provide a new bridge that is wider and has a better alignment. From Figure 115, the new bridge in the project case provides an MRS of 15 and a straight horizontal alignment.

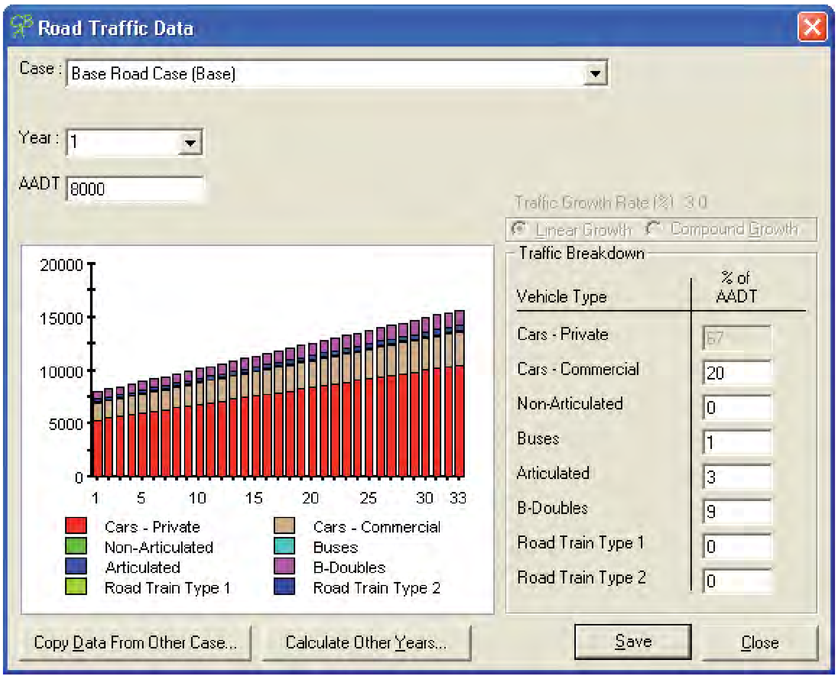
Figure 115: Road details for new bridge



5.5.1.4 Road traffic data

The road traffic data for the flood affected section of road is the same for the base case and the project case. The AADT is 8000 in Year 1 with a linear growth rate of 3% per annum, see Figure 116. System users should note that CBA6 uses the same traffic configuration for both the project case and the diversion case.

Figure 116: Road traffic data flood affected section



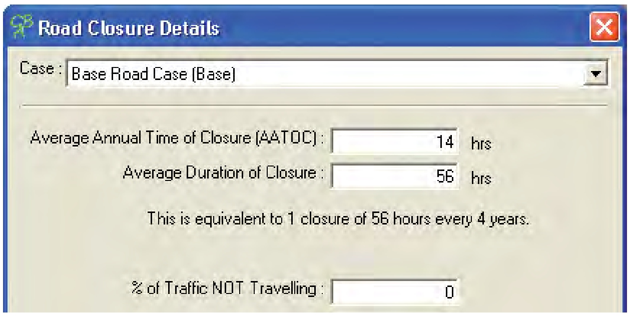
5.5.1.5 Road closure details

The 'road closure details' screen displays the main inputs for a flood immunity improvement project. Here the system user is required to develop a pattern of road user behaviour when the road is flooded.

The flooding history of the road indicated an AATOC of 14 hours over the last 20 years. The duration of a flooding event at the site lasted 56 hours on average. In Figure 117 the behaviour of motorists is classified according to traffic not travelling, traffic waiting and those users that divert via an alternative route during a flooding event. Given that an average flooding event at a project site lasts for 56 hours, it is logical to assume that many road users will not wait at the project site, therefore only 10% of the traffic will choose to wait at the flood site. This proportion of the fleet represents local traffic. The remaining 90% of the traffic will choose to divert the additional 40 km.

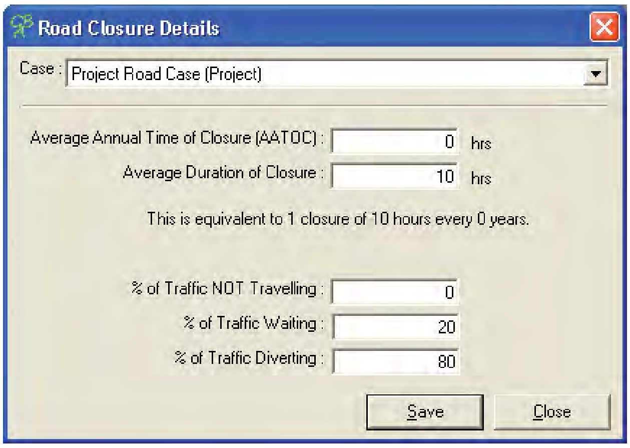
Note: Traffic that chooses not to travel during the closure period will not incur any road user costs. Where the proportion of traffic that chooses not to travel is high, the system user should seek specialist advice to calculate these economic costs. In this example the percentage of vehicles travelling is zero. For simplicity the cost of not travelling has therefore been excluded from the analysis.

Figure 117: Base case road closures



The bridge to be built in the project case is designed to a Q100 standard. Based on historical flood levels, the average duration of closure for this bridge would be 10 hours. Traffic behaviour is assumed to change, as the time of closure is lower than in the base case. Details for the project case road closure is shown below in Figure 118. It has been assumed that 20% of road users will wait for flood levels to subside due to the lower average duration of closure.

Figure 118: Project case road closure details



Road Closure Details

Case : Project Road Case (Project)

Average Annual Time of Closure (AATOC) : 0 hrs

Average Duration of Closure : 10 hrs

This is equivalent to 1 closure of 10 hours every 0 years.

% of Traffic NOT Travelling : 0

% of Traffic Waiting : 20

% of Traffic Diverting : 80

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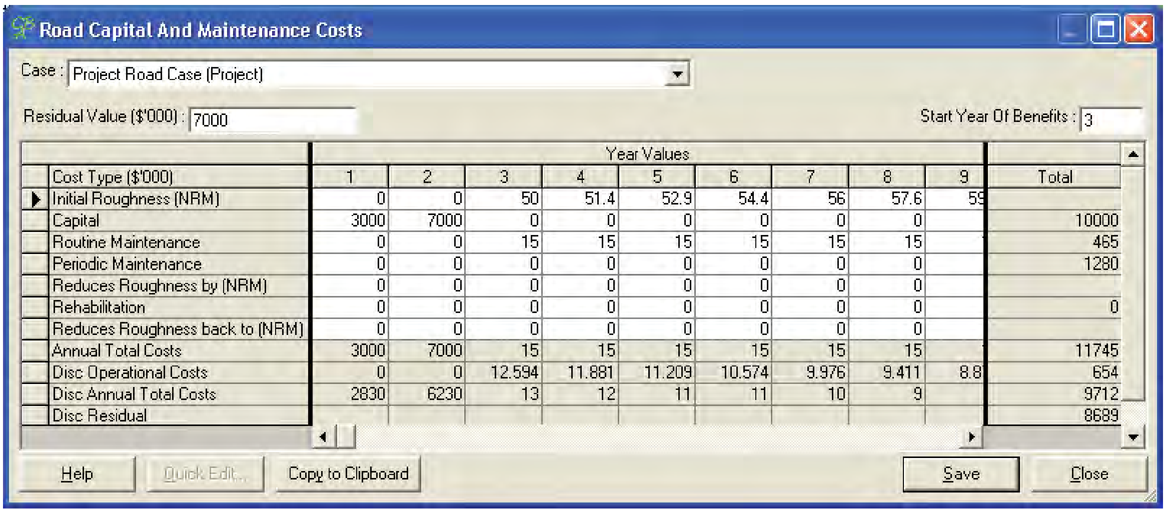
Note: The AATOC for a Q100 bridge with an average duration of closure would be 0.1 hours (10 hours divided by 100 years). In CBA6 the AATOC and ADC can only be measured in hours, therefore in this example the AATOC has been rounded down to zero.

5.5.1.6 Capital and maintenance costs

The estimated capital costs for the project is $10 million. The expected breakdown of costs for the project is $3 million in Year 1 and $7 million in spending for Year 2. The project will open to road users in Year 3 and CBA6 will calculate benefits from this time, see Figure 119. The bridge is expected to have a useful life of 100 years, therefore a residual value has been developed to value the useful life of the bridge after the 30-year evaluation period has ended. See Section 9.7 of the *Technical Guide* for formulas to calculate the residual value.

Figure 119: New bridge costs



Road Capital And Maintenance Costs

Case : Project Road Case (Project)

Residual Value ($'000) : 7000

Start Year Of Benefits : 3

	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	0	50	51.4	52.9	54.4	56	57.6	59	
Capital	3000	7000	0	0	0	0	0	0		10000
Routine Maintenance	0	0	15	15	15	15	15	15		465
Periodic Maintenance	0	0	0	0	0	0	0	0		1280
Reduces Roughness by (NRM)	0	0	0	0	0	0	0	0		
Rehabilitation	0	0	0	0	0	0	0	0		0
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	3000	7000	15	15	15	15	15	15		11745
Disc Operational Costs	0	0	12.594	11.881	11.209	10.574	9.976	9.411	8.8	654
Disc Annual Total Costs	2830	6230	13	12	11	11	10	9		9712
Disc Residual										8689

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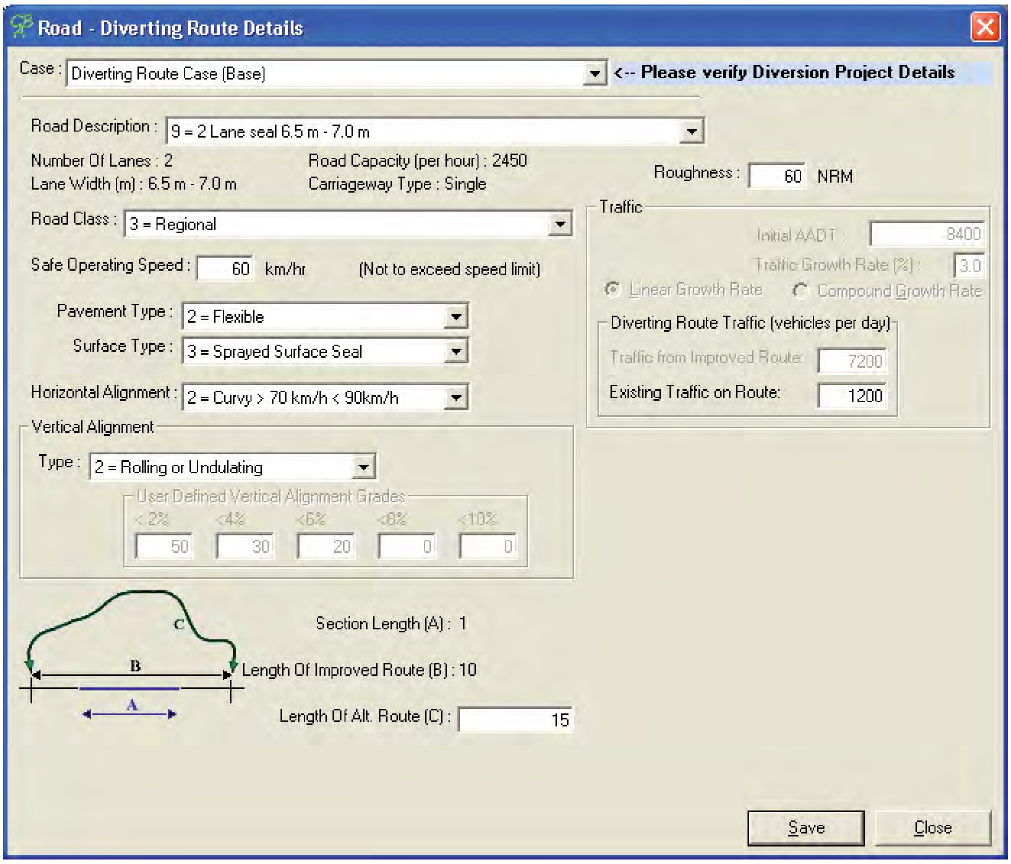
5.5.1.7 Accident and other costs

Accident costs will be automatically calculated by CBA6. The project provides savings in accident costs due to the change in MRS. During periods of road closure, increased traffic volumes will result in increased accidents on the diversion route, as diverting traffic will mix with existing road users. See Appendix C for a more detailed breakdown of benefits. Existing traffic volumes are used in CBA6 to determine the extent of congestion on the diverting route but no benefits or costs are attributed to them in the evaluation. See Section 8.1 of the *Technical Guide* for further explanations.

5.5.1.8 Diverting route road details

In this example the only available diversion route is a regional road. The traffic on the diversion route is referred to as existing traffic. In this example there are 1200 road users per day on the alternative route. The length of the alternative diversion route is 15 km, see Figure 120.

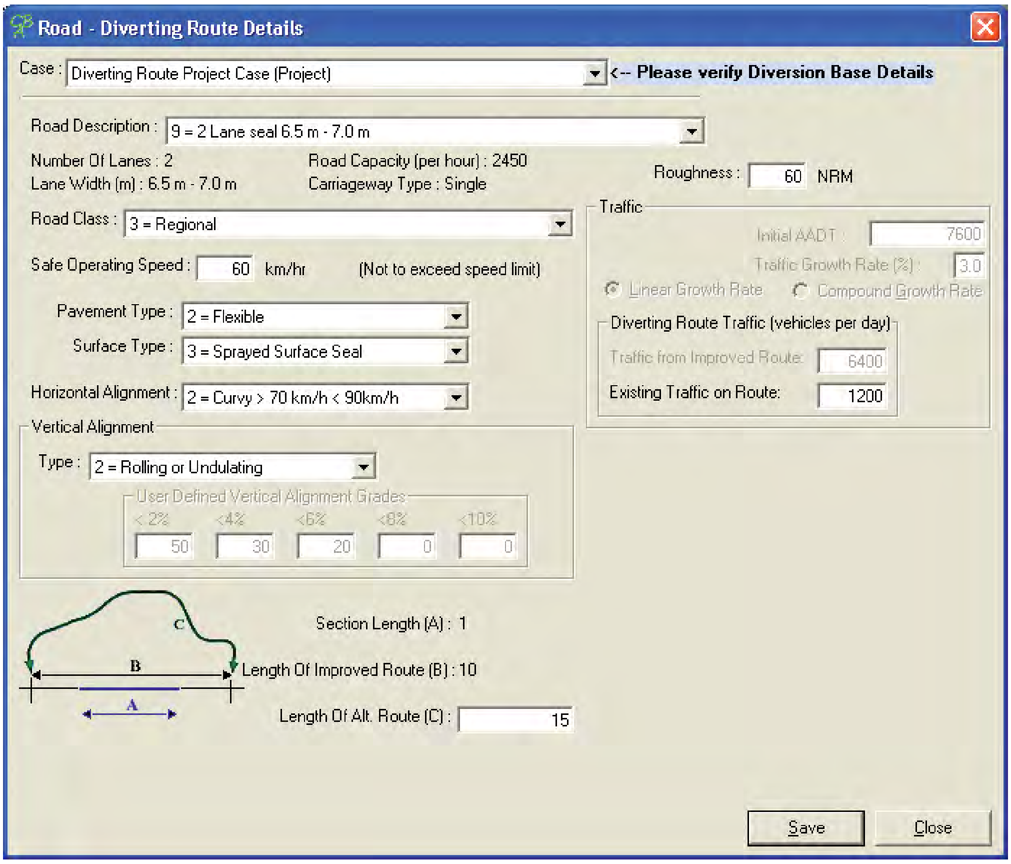
Figure 120: Base case diversion route details



System users can edit the project case diversion route details using the 'case' drop-down menu. In this example the project case diversion route has the same characteristics as the base case, see Figure 121.

The 'project case details' screen can be accessed to confirm the project case details, but any changes to the project case will also change the base case. The only variable that will change is the traffic data. Only 6400 road users will choose to divert in the project case compared with 7200 in the base case. This reflects the change in driver behaviour between the base and project cases. The new bridge in the project case has a shorter closure period. This means more road users will wait for the flood waters to subside and fewer road users will be inclined to travel the extra distance on the diversion route.

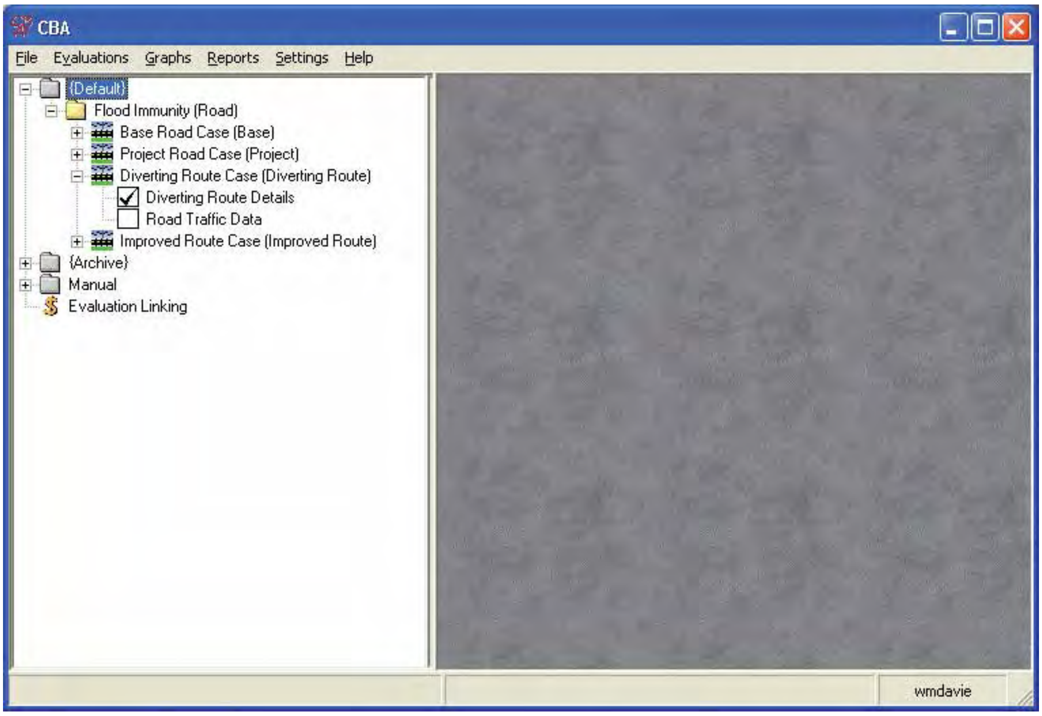
Figure 121: Project case diversion route details



5.5.1.9 Diverting route traffic data

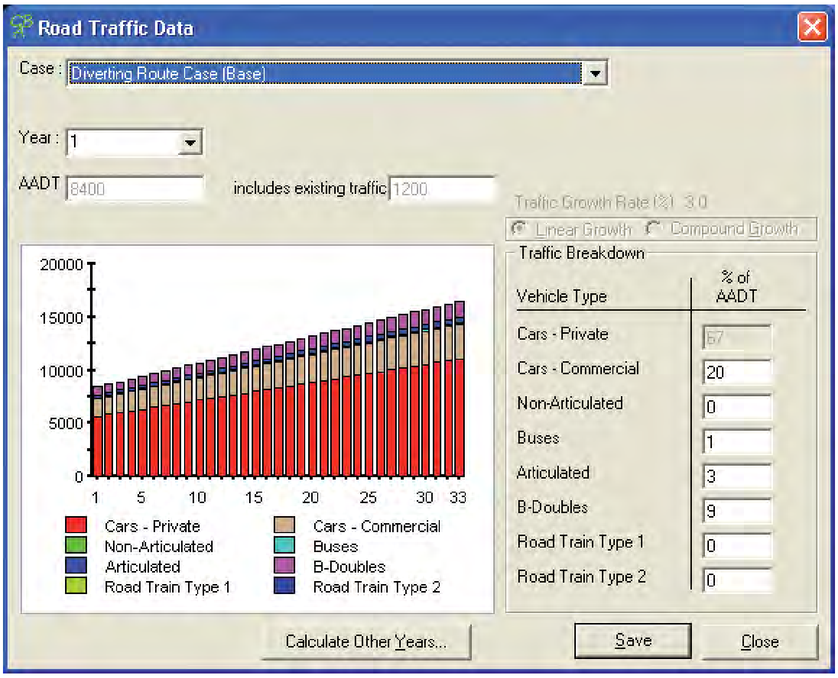
The road traffic data for the diversion route is the next required input, see Figure 122.

Figure 122: Diverting route workspace



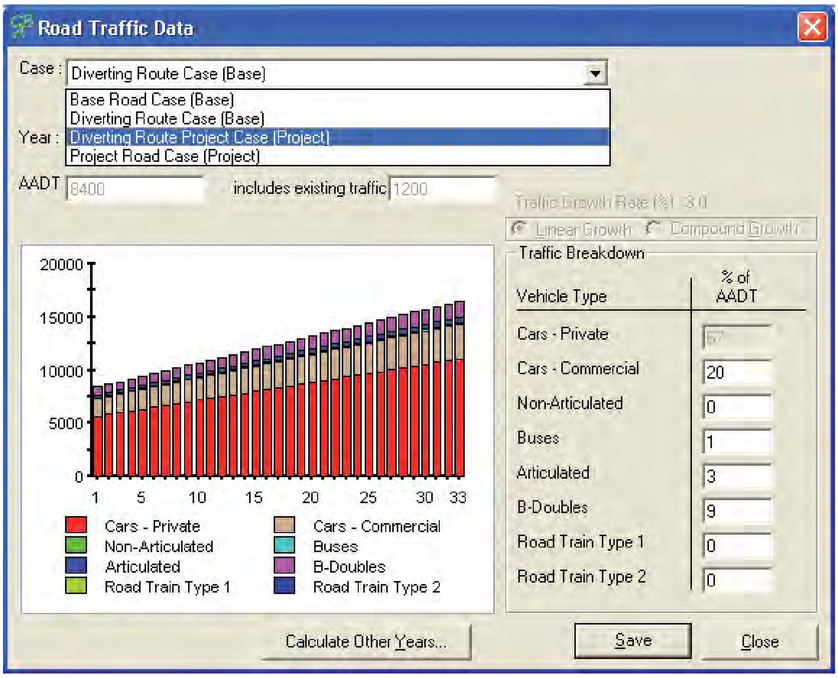
The only available option for system users is to adjust the traffic breakdown for the diversion route, as the initial AADT will be calculated automatically from CBA6 using data previously input by the system user. System users will note that the AADT includes the existing traffic on the diversion route, see Figure 123. In this case study, traffic breakdown of existing traffic is the same as diverting traffic.

Figure 123: Base case diverting route traffic



System users must also complete the diverting route project case road traffic data, see Figure 124.

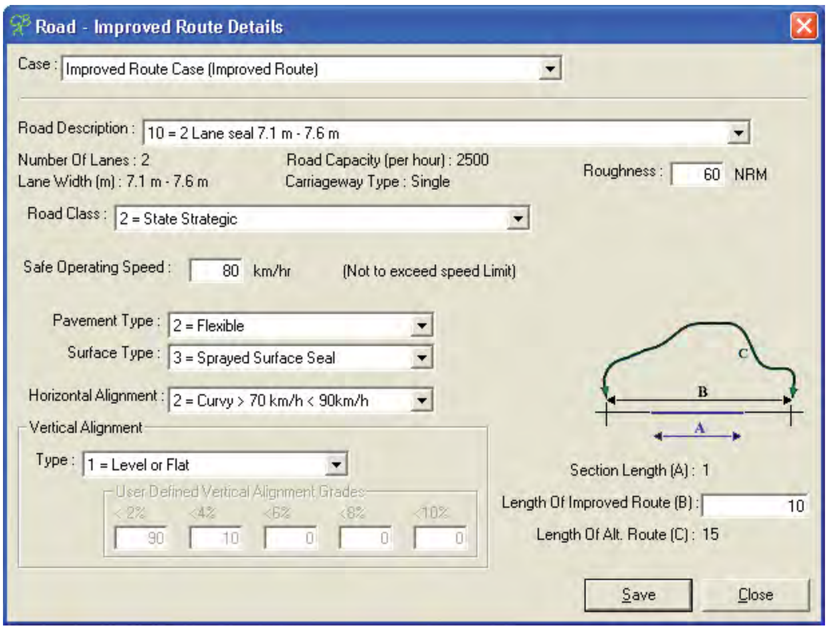
Figure 124: Project case diverting route



5.5.1.10 Improved route details

The improved route is the normal section of road that is used when the road is open to traffic (Section B in Figure 110). The system user is required to define the length of the improved route from the beginning to the end of the diversion route. The improved route will therefore remain the same between the base and project cases. In Figure 125, the improved route is shown as 10 km (includes the 1 km for Section A).

Figure 125: Improved route details



5.5.1.11 Results and decision criteria

In this example, the proposed project involves construction of a new bridge with Q100 flood immunity. The project has a total discounted capital cost of $9 million at the 6% discount rate. There are some savings in costs due to the inclusion of the residual value.

The majority of project benefits comprise TTC savings for road users. In the base case road users suffered delays waiting for flood waters to subside and increased journey times via the diversion route. This new bridge provides a better flood immunity for the site. The 'discounted road closure savings' row shows the delay costs for road users waiting for flood levels to subside. There is a saving of $3.6 million in waiting costs.

The NPV for the project is over $19.8 million at the discount rate of 6%. An NPV above zero is an indicator that the project will improve economic welfare. The BCR for the new bridge is 4.33 at the discount rate of 6% which suggests that the project is economically viable.

Figure 126: Flood immunity improvement results

Results - Decision Criteria Recalc No 15

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	4,737,380	5,947,566	6,325,454	6,601,038	6,938,043
Discounted Capital Costs	9,356,509	9,060,164	8,917,809	8,779,150	8,512,397
Discounted Other Costs	-4,619,128	-3,112,598	-2,592,355	-2,178,111	-1,574,353
Discounted Benefits	34,745,741	25,749,774	22,434,572	19,691,885	15,485,672
Private TTC Savings	1,782,037	1,333,206	1,165,745	1,026,205	810,210
Commercial TTC Savings	3,567,288	2,656,193	2,318,752	2,038,747	1,607,606
Private VOC Savings	10,582,738	7,832,107	6,820,060	5,983,581	4,702,351
Commercial VOC Savings	11,226,575	8,311,098	7,238,073	6,351,027	4,991,990
Discounted Accident Savings	2,712,962	2,008,563	1,749,239	1,534,831	1,206,287
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	4,874,142	3,608,608	3,142,704	2,757,495	2,167,228
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	30,008,361	19,802,208	16,109,117	13,090,847	8,547,628
Net Present Value per dollar Investment	3.21	2.19	1.81	1.49	1.00
Benefit Cost Ratio Excl. Private Time	6.96	4.11	3.36	2.83	2.12
Benefit Cost Ratio	7.33	4.33	3.55	2.98	2.23
First Year Rate of Return	15.30%	14.93%	14.74%	14.56%	14.21%

N.B. Results exclude savings and costs for Existing traffic on Diversion Route

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Note: To test for any uncertainty in the input data, system users can re-run the evaluation under different assumptions such as changes to the time of closure details, traffic behaviour during road closures or existing traffic on the diversion route. Alternatively, the sensitivity results shown in the printed CBA6 report can be used as a reference point.

5.5.2 Road closure (without diversion)

The road closure module in CBA6 is used for projects that are associated with frequent road closures without suitable diversion routes. As is the case with the road closure with diversion module, the road closure module will require system users to possess a wide range of data inputs and also have some understanding of local traffic conditions.

The following two options exist for road users affected by flooded roads:

- Wait – remain at the flood site for waters to subside.
- Do not travel – choose not to travel at all.

Before undertaking a flood immunity improvement project, the system user must be in possession of project data including AATOC and ADC for the base and project cases.

5.5.2.1 Road closure case study

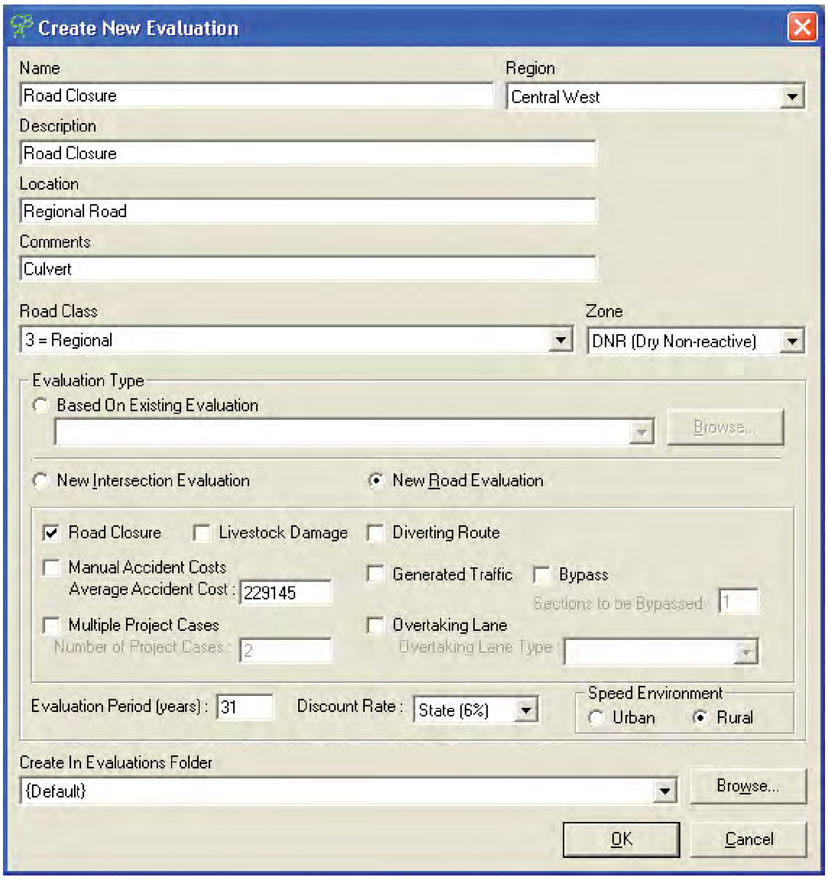
This case study involves a low lying road that floods during the wet season. This occurs every year with an average duration of closure of 12 hours. This road is an important freight link used by a number of heavy vehicles. As there is no suitable diversion route, it is assumed that all vehicles will wait at the flood affected site.

TMR will raise the height of the road through earth works and provide a culvert to eliminate future road closures.

5.5.2.2 Create new evaluation

To create a road closure project the system user must ensure the 'road closure' box is ticked, see Figure 127.

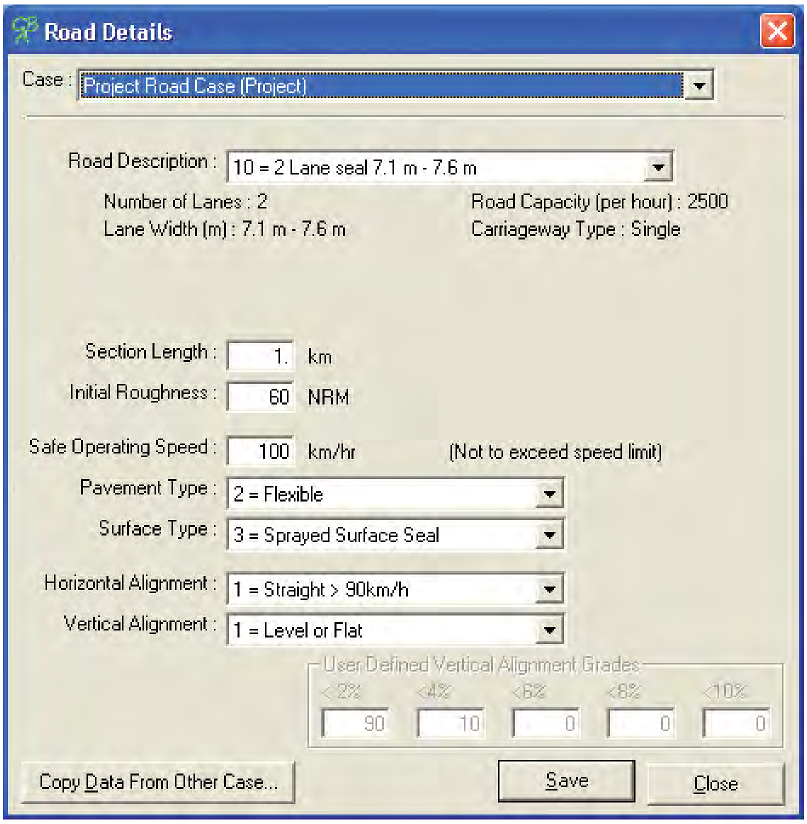
Figure 127: Road details for culvert



5.5.2.3 Road details

The 'road details' screen describes the section of road to be upgraded and improved in the project case. The current road has a roughness of 110 NRM while the project works will provide a new seal of 60 NRM, see Figure 128. All other input data will remain the same.

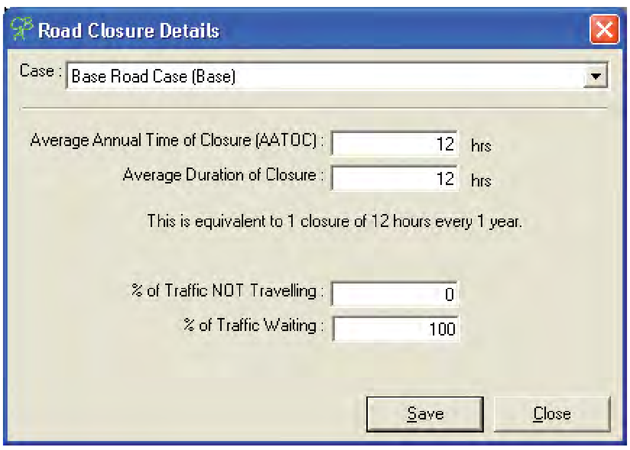
Figure 128: Closure road details



5.5.2.4 Road closure details

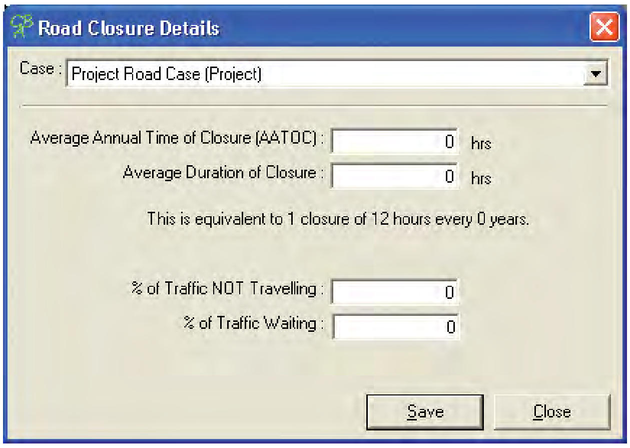
Historical records suggest that this road floods for 12 hours every year. In the base case the AATOC is 12 hours and the corresponding ADC is 12 hours, therefore the estimated frequency of road closures over the evaluation period is one closure of 12 hours every year, see Figure 129. Longer road closures are likely to result in less traffic waiting at the project site and more traffic choosing not to travel (see Section 5.5.1 for further information on the costs of not travelling). As there is no suitable alternative route in this case study, it is assumed that all vehicles will wait at the project site for the flood to subside. If an alternative route is available some vehicles will elect to use it.

Figure 129: Base case road closures



New culvert and earthworks will eliminate all future road closures caused by flooding. Road closure details for the project case are shown in Figure 130.

Figure 130: Project case road closures



5.5.2.5 Capital and maintenance costs

Construction will occur over a one-year time frame. The estimated cost for the project is $800 000 with the project being commissioned in Year 2. It is assumed that maintenance capital costs will remain the same in the base and project cases, therefore the net result will be zero.

5.5.2.6 Accident and other costs

Accident costs will be calculated automatically by CBA6. However as there is no change in MRS between the base and project cases there are no accident cost savings recorded.

5.5.2.7 Results and decision criteria

In this example, a culvert will be built to stop the frequent flooding that occurs along a regional road. The road closure savings for this project are over $1 million while the BCR is 1.69 at the 6% discount rate. The FYRR for the project of 8.77% shows that at current traffic volumes, immediate construction of the project is warranted.

Figure 131: Road closure results

Results - Decision Criteria Recalc No 3

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	769,231	754,717	747,664	740,741	727,273
Discounted Capital Costs	769,231	754,717	747,664	740,741	727,273
Discounted Other Costs	0	0	0	0	0
Discounted Benefits	1,676,538	1,272,791	1,121,611	995,355	799,281
Private TTC Savings	22	12	9	7	4
Commercial TTC Savings	130,076	98,795	87,077	77,287	62,078
Private VOC Savings	17,942	13,624	12,006	10,656	8,557
Commercial VOC Savings	146,759	111,395	98,156	87,102	69,938
Discounted Accident Savings	0	0	0	0	0
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	1,381,740	1,048,966	924,363	820,304	658,703
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	907,307	518,074	373,947	254,615	72,008
Net Present Value per dollar Investment	1.18	0.69	0.50	0.34	0.10
Benefit Cost Ratio Excl. Private Time	2.18	1.69	1.50	1.34	1.10
Benefit Cost Ratio	2.18	1.69	1.50	1.34	1.10
First Year Rate of Return	8.93%	8.77%	8.68%	8.60%	8.45%

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5.6 Intersection

Intersection evaluations can be undertaken in CBA6 using the intersection module. CBA6 has been designed to use output information from the SIDRA intersection performance tool. Before undertaking an economic evaluation in CBA6, the system user will require traffic modelling results from SIDRA. System users should seek support from the CBA Team when using alternative traffic models.

The CBA6 intersection module takes into account queuing behaviour and delays within the boundaries of the intersection and determines the impact on travel time and fuel costs. Changes in VOC other than fuel are not calculated by CBA6 or SIDRA.

The intersections module is best used for evaluating projects which are not expected to have significant network effects. A transport network model or microsimulation tool should be used if the intersection under evaluation is expected to have significant effects on traffic volumes or speeds of connecting links.

The CBA6 intersection module can be used for:

- intersection only projects such as replacing an unsignalised intersection with a roundabout or signals
- intersection projects which are expected to cause traffic diversions to or from alternate routes. The evaluation would be made up of composite runs of CBA6 using the intersection module and the normal road module of CBA6 for estimating benefits to existing and diverting traffic. The 'linking projects' function would be used to combine the individual components into a total project, see Section 5.13.

Note: CBA6 has been specifically designed to use outputs from SIDRA, although it may be possible to use outputs from other intersection modelling tools. System users should consult with the CBA Team before attempting to use outputs from other modelling tools.

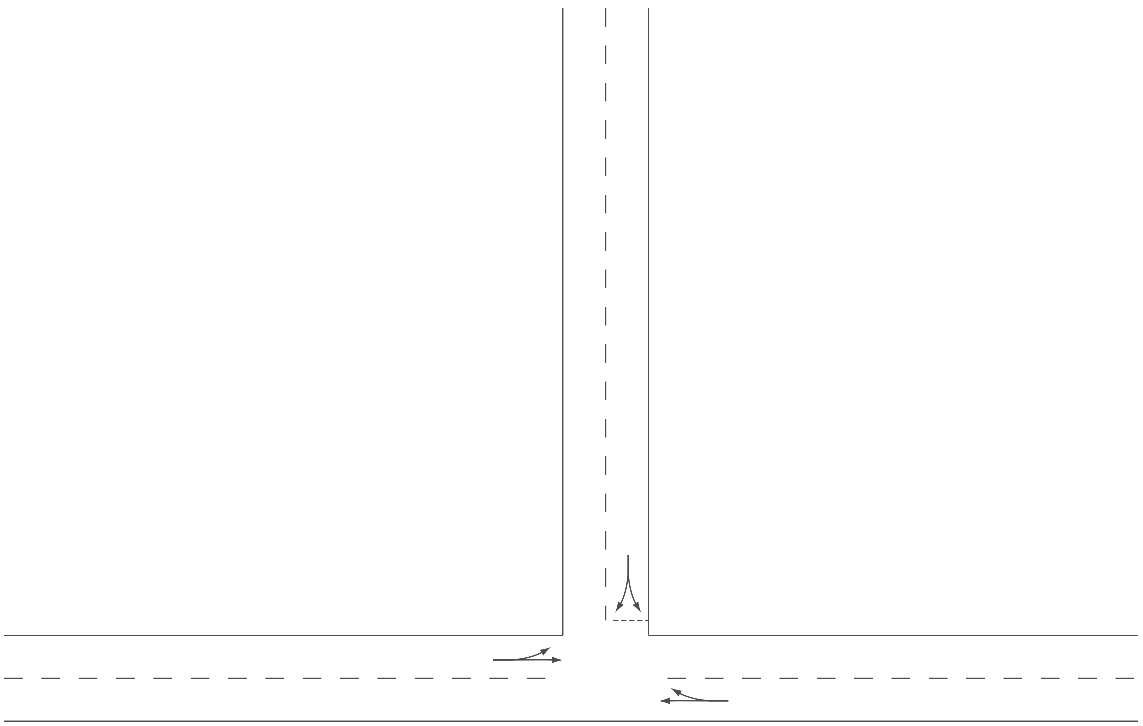
5.6.1 Intersection case study

This case study involves the signalisation of a simple intersection which connects a local road to an arterial road. Currently, a stop sign on the local road controls vehicular access to the arterial road. During afternoon peak periods there are significant delays to traffic merging onto the arterial road. The intersection is currently oversaturated. A signalised intersection will reduce these delays and increase safety at the site by controlling all vehicle movements. The project will take one year to construct and will have a useful life of 10 years. To determine the savings in delay times, a SIDRA analysis was undertaken on both the current intersection and the new signalised intersection. The results of the SIDRA analysis for the base case (stop sign) intersection are shown in Table 4. Figure 132 illustrates the structure of the T intersection.

Table 4: SIDRA base case (unsignalised)

Year	Period	Duration (hours)	Vehicles per hour	Average delay (S/veh)	Fuel consumption (L/h (total)
Year 1	Morning peak	1	2,203	28.2	152.7
	Afternoon peak	1	2,361	36.3	161.8
Year 11	Morning peak	1	2,646	181.1	335.3
	Afternoon peak	1	2,835	327	503.4

Figure 132: Intersection layout



The results of the SIDRA analysis for the project case (signalised) intersection are shown in Table 5.

Table 5: SIDRA project case (signalised)

Year	Period	Duration (hours)	Vehicles per hour	Average delay (S/veh)	Fuel consumption (L/h (total)
Year 1	Morning peak	1	2,203	4.4	122.5
	Afternoon peak	1	2,361	3.7	126.7
Year 11	Morning peak	1	2,646	56.9	235.5
	Afternoon peak	1	2,835	6.7	172.2

Note:

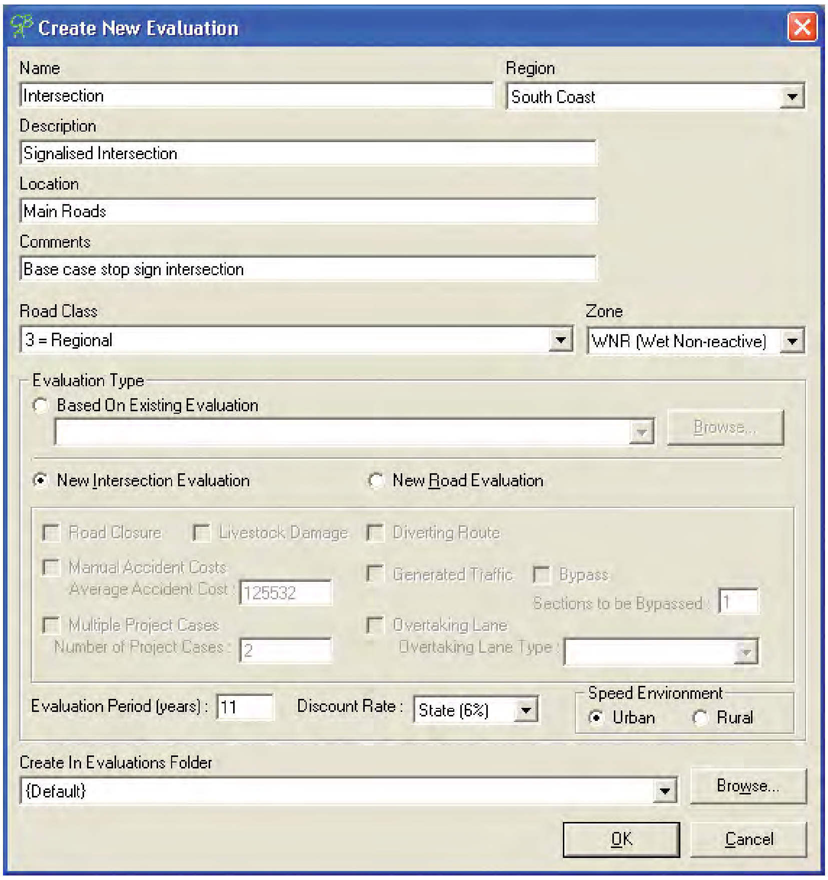
- The operation of the signals in combination with the large volume of traffic coming from the east in the morning reduces the effectiveness of the signals in the morning peak period relative to the afternoon peak period.
- Data for Years 1 to 11 will be interpolated by CBA6 using a simple liner technique, see Section 5.5.3.

5.6.2 Create new evaluation

To create a new intersection evaluation, ensure the 'new intersection evaluation' option is selected, see Figure 133. This will disable all other evaluation modules.

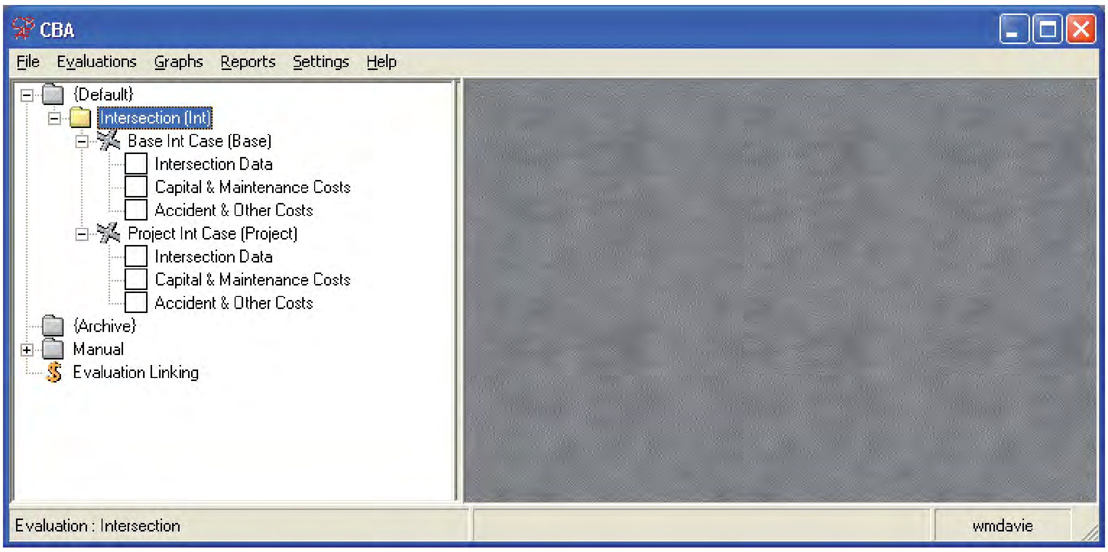
Note: The evaluation period is 11 years which includes one year for construction and 10 years of operation. The urban speed environment is selected as the project is located in the middle of a town.

Figure 133: Intersection new evaluation



The intersection module operates from a different node tree to road projects modules. From Figure 134, the new input field is 'intersection data'. The 'intersection data' screen is where the SIDRA data is required to be input.

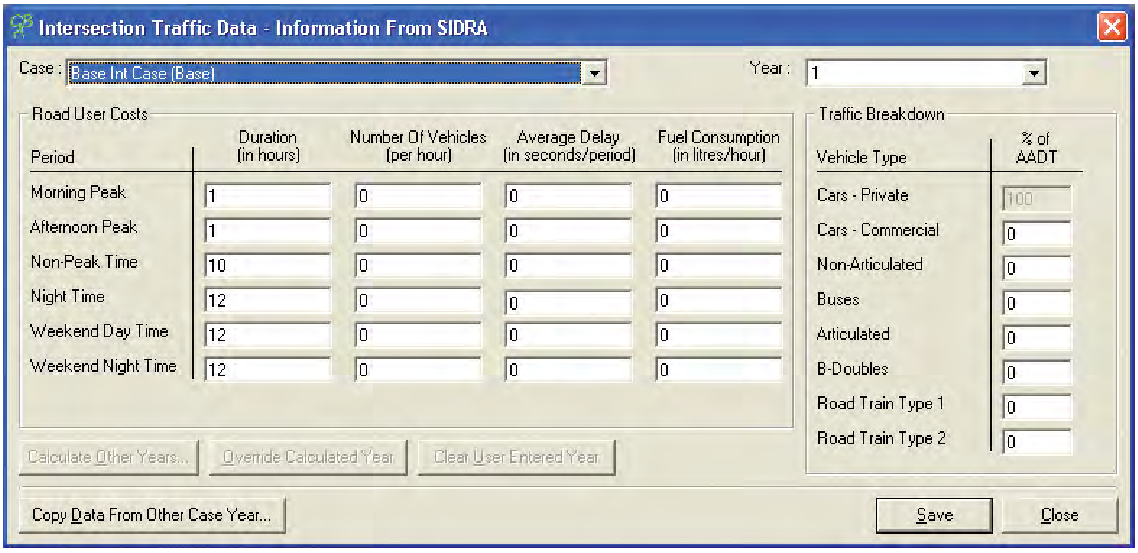
Figure 134: Intersection workspace



5.6.3 Intersection data

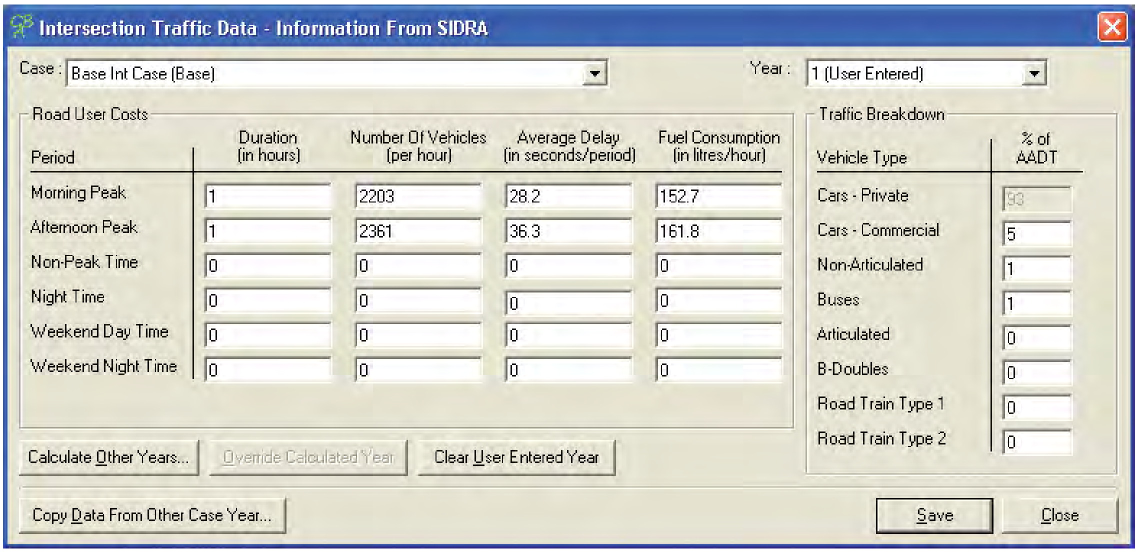
For this case study, the SIDRA analysis was only undertaken for the peak morning and afternoon periods of the day. The default time periods for an analysis in CBA6 include the peak periods, non-peak periods, night and weekends, see Figure 135.

Figure 135: Intersection traffic data



To input the base case data, fill in the required fields in Figure 136. After entering the data for Year 1, click ‘save’.

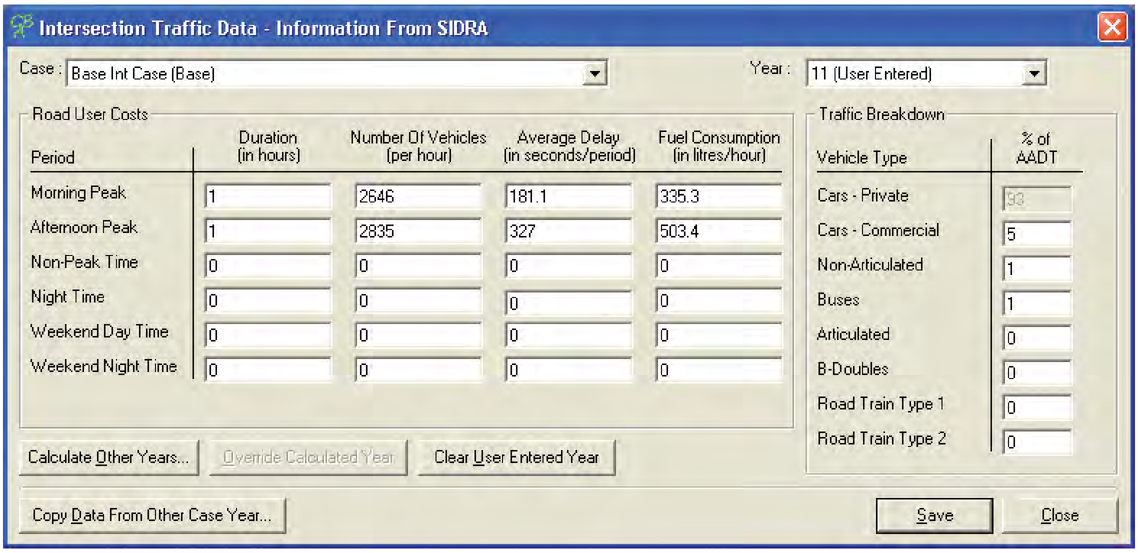
Figure 136: Base case intersection data Year 1



Note: Generally SIDRA analysis will only be undertaken for the peak periods. When this is the case, all other periods must be set to zero.

The next step requires the system user to enter the final year of SIDRA data in Year 11, see Figure 137.

Figure 137: Base case intersection data Year 11



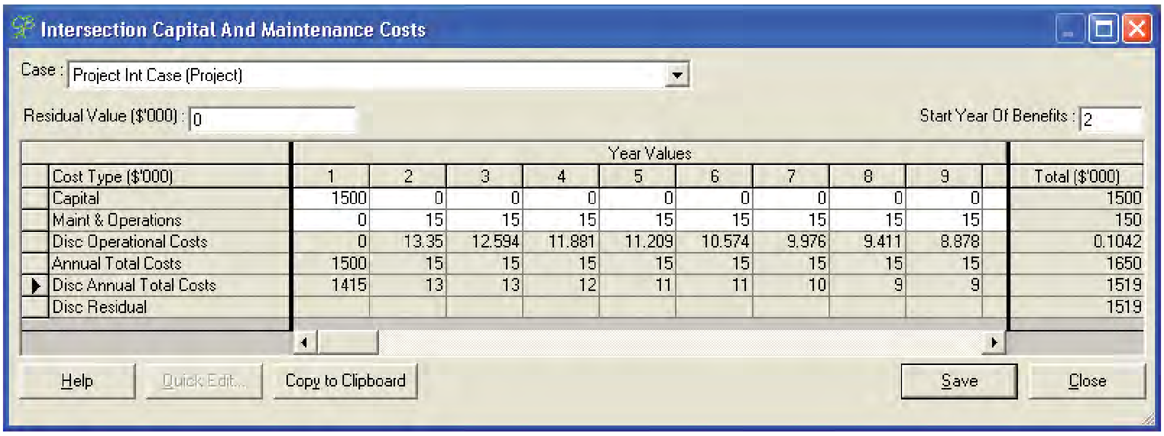
To calculate the SIDRA results for the remaining years, CBA6 interpolates the data from Years 1 to 11. From Figure 138 the system user is required to use the 'calculate other years' button. This process is repeated for the project case SIDRA data.

Figure 138: Calculate other years

5.6.4 Capital and maintenance costs

Current maintenance and operational costs for the base case (stop sign controlled intersection) is $2000 per annum. The capital costs for the new signalised intersection are estimated at $1.5 million and will cost $15 000 each year to operate, see Figure 139.

Figure 139: Intersection costs



	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total ($'000)
Capital	1500	0	0	0	0	0	0	0	0	1500
Maint & Operations	0	15	15	15	15	15	15	15	15	150
Disc Operational Costs	0	13.35	12.594	11.881	11.209	10.574	9.976	9.411	8.878	0.1042
Annual Total Costs	1500	15	15	15	15	15	15	15	15	1650
Disc Annual Total Costs	1415	13	13	12	11	11	10	9	9	1519
Disc Residual										1519

5.6.5 Accident and other costs

Accident costs in the intersection module have to be calculated manually by the system user. In this case study accident costs for the base case are $50 000 per year. The improved safety conditions in the project case reduced accident costs to $25 000 per year. For detail on the manual calculation of accident costs, see Section 6 of the *Technical Guide*. Accident costs can also be calculated by using DCA codes.

See Section 7 of the *Technical Guide* for further details on externality costs.

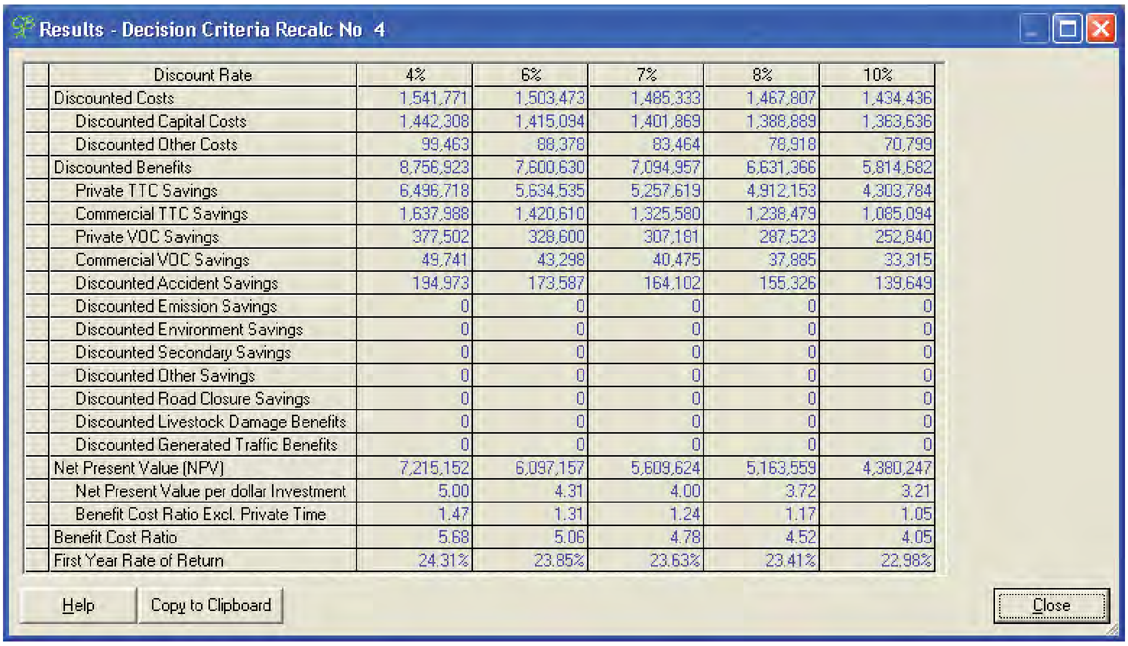
5.6.6 Results and decision criteria

In this case study, the proposed project provides a signalised intersection as an alternative to a stop sign controlled environment. The project has a total discounted cost of $1.4 million at the 6% discount rate. There is an increase in the operational costs of the project to account for traffic systems and other costs associated with maintaining a signalised intersection.

TTC savings for private road users represent the majority of the benefits derived from this project. In the base case, road users suffer significant delays in the afternoon peak period. The new signalised intersection will significantly reduce delays and the associated over saturation of the intersection.

The results of this case study provide strong justification for the project. The NPV of $6.0 million at the discount rate of 6%, and a BCR of 5.06 suggest that the signalisation of this intersection will yield significant economic benefits, see Figure 140. The BCR is particularly high due to the significant reduction in travel delays as a result of the signalised intersection.

Figure 140: Intersection results and decision criteria



Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	1,541,771	1,503,473	1,485,333	1,467,807	1,434,436
Discounted Capital Costs	1,442,308	1,415,094	1,401,869	1,388,889	1,363,636
Discounted Other Costs	99,463	88,378	83,464	78,918	70,799
Discounted Benefits	8,756,923	7,600,630	7,094,957	6,631,366	5,814,682
Private TTC Savings	6,496,718	5,634,535	5,257,619	4,912,153	4,303,784
Commercial TTC Savings	1,637,988	1,420,610	1,325,580	1,238,479	1,085,094
Private VOC Savings	377,502	328,600	307,181	287,523	252,840
Commercial VOC Savings	49,741	43,298	40,475	37,885	33,315
Discounted Accident Savings	194,973	173,587	164,102	155,326	139,649
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	7,215,152	6,097,157	5,609,624	5,163,559	4,380,247
Net Present Value per dollar Investment	5.00	4.31	4.00	3.72	3.21
Benefit Cost Ratio Excl. Private Time	1.47	1.31	1.24	1.17	1.05
Benefit Cost Ratio	5.68	5.06	4.78	4.52	4.05
First Year Rate of Return	24.31%	23.85%	23.63%	23.41%	22.98%

5.7 Duplication

A road duplication project is designed to double the existing lanes of a road. Road duplications are commonly applied to arterial roads or highways where there is sufficient demand to warrant a major upgrade. The purpose of a road duplication is to provide increased road capacity to enable traffic volumes to continue to grow.

Note: Road duplication projects are sometimes referred to as road widening projects. Road widening refers to increasing only the seal width of a road. Highway upgrades from four to six lanes are not technically referred to as a duplication. Also road duplication projects are often associated with an increase in traffic demand above the underlying growth which results in 'generated traffic'. If a road duplication initiative generates additional traffic, the system user should follow the example set out in Section 5.9.

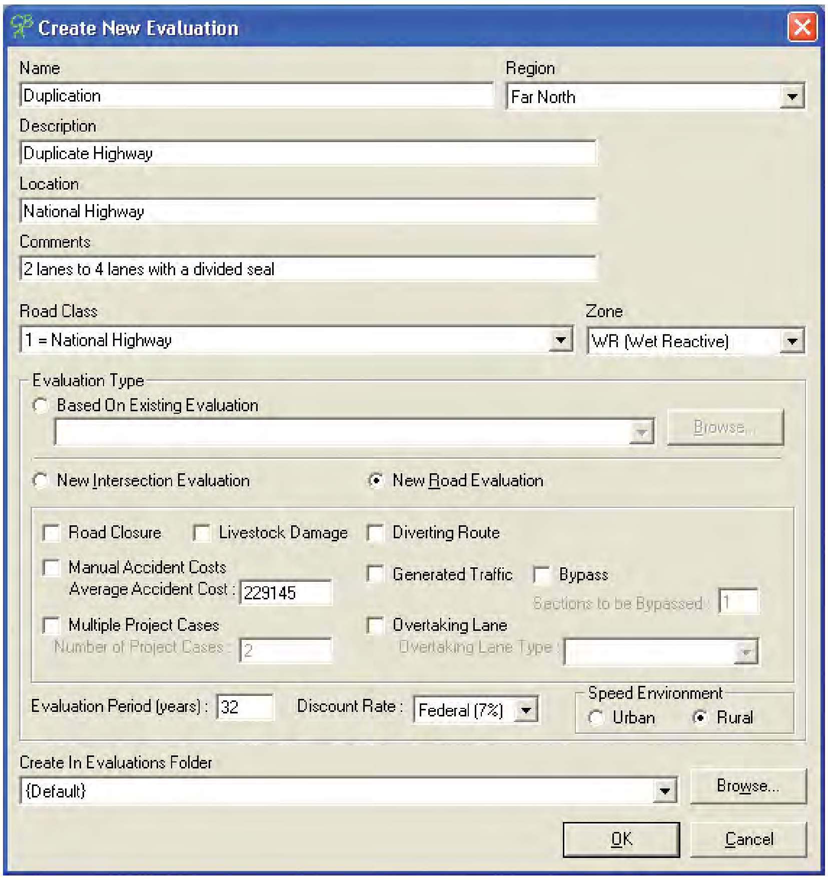
5.7.1 Duplication case study

This case study involves the evaluation of a two-lane highway that requires duplication. Currently 12 000 vehicles per day use the highway and growth of 5% per annum is assumed. The proposed project will duplicate the road for 3 km and provide a divided seal to increase safety.

5.7.2 Create new evaluation

The 'create new evaluation' screen is similar to other case studies. No advanced modules need to be selected, see Figure 141. All case study data is shown in Appendix A.

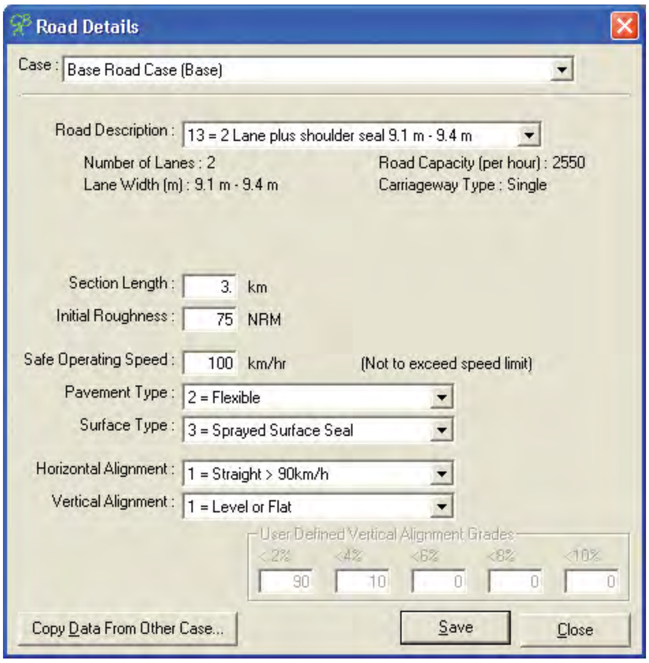
Figure 141: Duplication evaluation



5.7.3 Road details

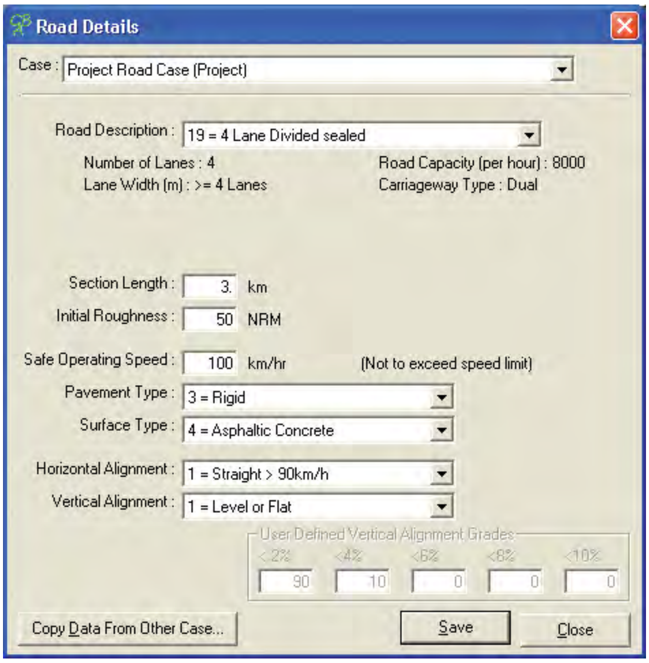
The main input used in a duplication project is the MRS. In the base case, the current road is two lanes with a seal width of 9.4 metres and sealed shoulders, see Figure 142.

Figure 142: Base case road details 2 lanes



The project will significantly upgrade the road to a four-lane divided highway with an improved surface. From Figure 143 an MRS of 19 is selected in the project case. The default pavement and surface types for MRS 19 are rigid and concrete respectively.

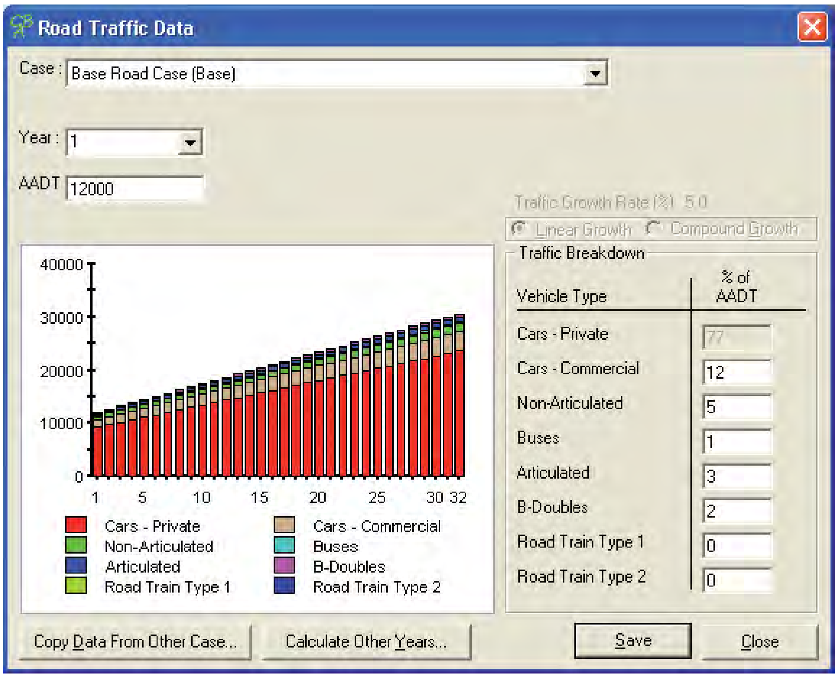
Figure 143: Duplication details



5.7.4 Road traffic data

The AADT is expected to remain the same between the base and project cases. Initial AADT is 12 000 with an annual growth rate of 5%, see Figure 144.

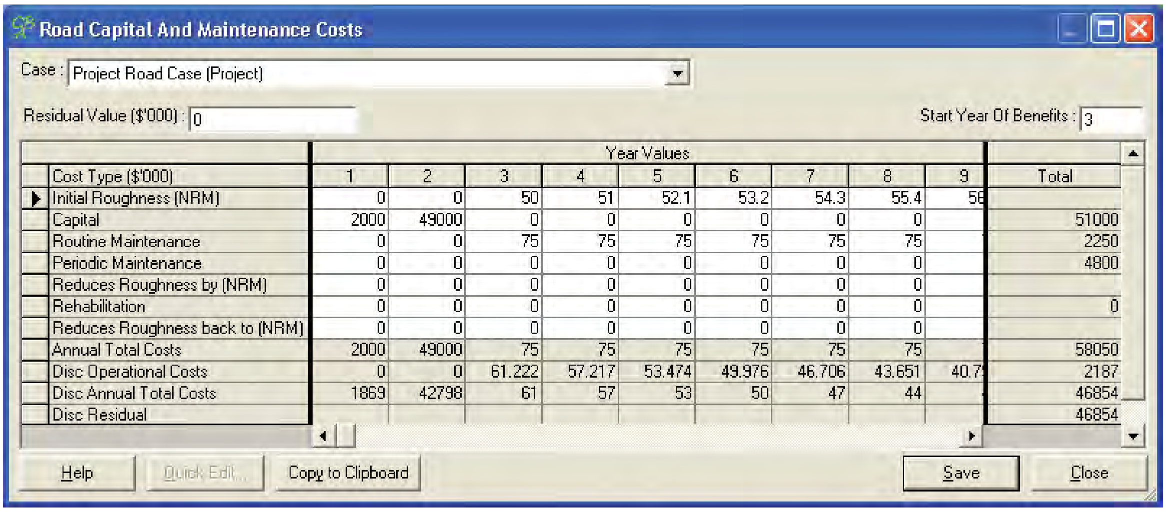
Figure 144: Duplication road traffic data



5.7.5 Capital and maintenance costs

The capital cost for the duplication is estimated at $51 million over two years. Initial site works will begin in Year 1, with the majority of the capital costs being incurred in construction during Year 2. Maintenance costs in the project case are estimated to more than double. Figure 145 shows the cost distribution for the project. The first year of operation will be in Year 3. All other costs, including base case maintenance costs, are shown in Appendix A.

Figure 145: Duplication costs



Road Capital And Maintenance Costs

Case : Project Road Case (Project)

Residual Value ($'000) : 0

Start Year Of Benefits : 3

	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	0	50	51	52.1	53.2	54.3	55.4	58	
Capital	2000	49000	0	0	0	0	0	0		51000
Routine Maintenance	0	0	75	75	75	75	75	75		2250
Periodic Maintenance	0	0	0	0	0	0	0	0		4800
Reduces Roughness by (NRM)	0	0	0	0	0	0	0	0		
Rehabilitation	0	0	0	0	0	0	0	0		0
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	2000	49000	75	75	75	75	75	75		58050
Disc Operational Costs	0	0	61.222	57.217	53.474	49.976	46.706	43.651	40.7	2187
Disc Annual Total Costs	1869	42798	61	57	53	50	47	44		46854
Disc Residual										46854

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5.7.6 Accident and other costs

The road duplication project and new divided seal will improve safety along the highway. Accident cost savings are estimated at over $3.3 million, see Figure 145. A highway with a divided seal is expected to provide a reduced accident rate. See Section 6 of the *Technical Guide* for further information on accident rates for each MRS.

5.7.7 Results and decision criteria

To cope with increasing traffic volumes along the highway, TMR has proposed a duplication to improve highway conditions. The BCR for the project is 1.75 while the NPV is $35 879 544 at the 4% discount rate. At the 7% discount rate, the BCR is 0.99 and the NPV is $593 015, see Figure 146. The large difference in NPV at the two discount rates can be explained by the low FYRR (1.57 and 1.53 at the 4% and 6% discount rates respectively) which implies that project benefits lie in the future. Delaying this project by a few years will improve its economic viability.

The majority of benefits are TTC savings. This is due to congestion in the base case. Private and commercial VOC savings for this project are negative. The results also show that private VOC benefits decrease at higher discount rates while commercial VOC benefits increase at higher discount rates. This is due to the relationship between operating speed and VOC for private vehicles. See Section 3 of the *Technical Guide* for further information on operating speed.

Figure 146: Duplication results

Results - Decision Criteria Recalc No 24

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	47,710,621	45,755,273	44,852,385	43,989,754	42,365,845
Discounted Capital Costs	47,226,331	45,496,618	44,667,657	43,861,454	42,314,050
Discounted Other Costs	484,290	258,655	184,728	128,300	51,796
Discounted Benefits	83,590,166	54,290,334	44,259,370	36,366,021	25,143,843
Private TTC Savings	49,020,494	31,818,995	25,924,981	21,284,894	14,684,690
Commercial TTC Savings	31,749,591	20,550,056	16,717,041	13,701,998	9,419,028
Private VOC Savings	-1,432,389	-1,040,125	-891,815	-767,851	-576,451
Commercial VOC Savings	-381,799	-453,956	-457,066	-447,946	-409,974
Discounted Accident Savings	4,634,268	3,415,364	2,966,228	2,594,925	2,026,550
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	35,879,544	8,535,061	-593,015	-7,623,733	-17,222,002
Net Present Value per dollar Investment	0.76	0.19	-0.01	-0.17	-0.41
Benefit Cost Ratio Excl. Private Time	0.72	0.49	0.41	0.34	0.25
Benefit Cost Ratio	1.75	1.19	0.99	0.83	0.59
First Year Rate of Return	1.57%	1.54%	1.53%	1.51%	1.48%

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5.8 Bypass

A bypass is a new road which reroutes traffic around a town or built-up area. There are different types of bypass projects, for example a bypass can be due to a rock fall or a flooding event. A bypass project involves the permanent re-route of a road whereas a diversion project is a temporary workaround. Evaluations of bypasses tend to be data intensive depending on the magnitude of the bypass. For example, in a town bypass, the project case has an origin from the proposed deviation and a destination where the bypass rejoins the original route. A bypass of this nature has the capacity to bypass multiple individual road links. In reality, bypassing a town will have a number of commercial and social impacts that may need to be evaluated. Due to the complexity of the bypass evaluations, system users must carefully consider the base case and the bypass option prior to attempting to establish the methodology. It is recommended that specialist advice be sought as early as practical. See Section 2.4.3 of the *Theoretical Guide* for more information on bypass evaluations.

A town bypass provides a separation between highway traffic and local commuters. Town bypasses can reduce local congestion, reduce highway traffic travel time, improve safety, reduce noise and increase air quality. This case study will provide a simple example of a town bypass. In this example the only impacts under consideration are road user costs and capital costs.

Note: This module can be used to evaluate projects where some vehicles need to divert around a road due to lack of proper access. For example, a low clearance bridge, or a bridge with a low load capacity, will require some vehicles to divert around the road via an alternative route.

5.8.1 Bypass case study

This case study involves the evaluation of a state-controlled highway that passes through a major rural town. Highway traffic passing through the town is delayed by reduced speed limits, congestion and delays at intersections. A proposed bypass of the town will provide TTC savings for highway traffic.

The new road will bypass four discrete sections of road from the existing highway. The sections to be analysed in the case study are shown in Figure 147. These sections currently carry between 4000 and 8000 vehicles per day. Of these, 2000 are passing through the town and are expected to divert to the proposed bypass. A large proportion of the traffic (around 23% of all trips), is for business purposes.

The capital costs of the proposed bypass are $85 million including simple intersection works at either end. In this case study, the effects of the intersection works on users and safety will be marginal. Note: In reality, intersections could be discretely analysed using the ‘intersections’ module, and combined with the results of the base case and project case sections using ‘link projects’.

5.8.1.1 Base case

The main street funnels highway traffic in both directions through the town. The purpose of this project is to divert highway traffic around the town through the construction of a bypass.

The existing route includes four sections. Sections 2 and 3 comprise the main street. Each section has the same model road state but the traffic volumes differ. Sections 1 and 4 have an AADT of 4000, and Sections 2 and 3 have an AADT of 8000. The first and fourth sections are part of the current highway alignment. These are included so that the base case and the project case have common end points.

The maximum speed along the main street is suppressed as a proxy for the impedance of intersections. To do this the ‘posted speed limit’ is specified at 40 km/h (this speed estimate will vary depending on the project).

Note: The bypass is not an element of the base case because it is at this stage only a proposal. If the bypass took the form of upgrading an existing route, that existing route with its current MRS, condition and traffic would be part of the base case.

5.8.1.2 Project case

The project case contains five sections. The first section is the proposed bypass or new road. The remaining four sections are the existing sections of road passing through the town. On each base case section, 2000 vehicles are assumed to divert to the project case route.

For simplicity, there is no generated traffic in the project case. Bypass projects such as this may generate traffic. Judgement needs to be made about the scope of analysis which can be achieved. It is usually best to leave generated traffic out of the analysis.

For simplicity, intersection effects at either end of the town are negligible.

Figure 147: Bypass

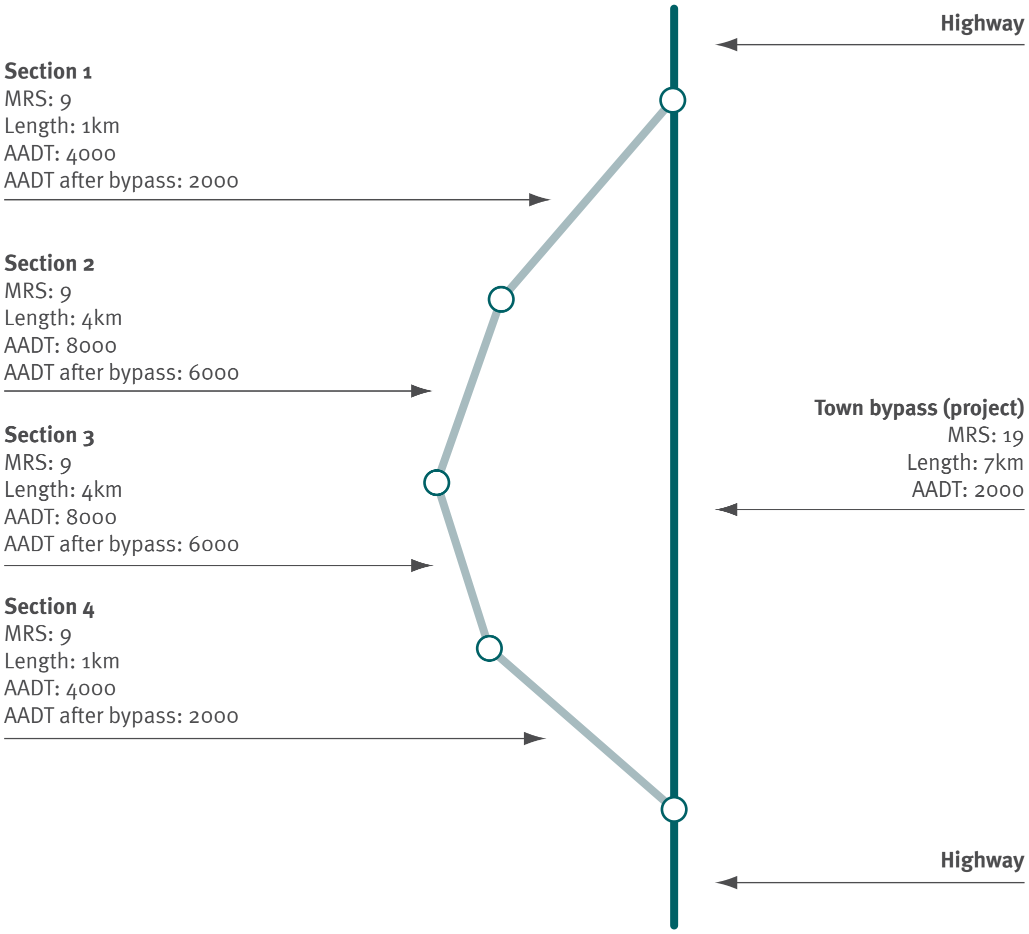


Table 6 shows the sections used in the case study. The first step is to identify the sections or segments making up the base and the project cases. If road descriptions and AADT vary frequently along the routes being evaluated, then the sections will be aggregated on a 'most common characteristics' basis. See Section 2.4.3 of the *Theoretical Guide* for more information on bypass evaluations.

Note: In this simplified case study, the safe operating speed on the existing road is assumed to be 40 for all four sections.

Table 6: Town bypass base and project case

Town bypass	Section 1		Section 2		Section 3		Section 4		Bypass	
	B	P	B	P	B	P	B	P	B	P
Mrs	9	9	9	9	9	9	9	9	N/a	15
Section length	1	1	4	4	4	4	1	1	N/a	7
Initial roughness	75	75	75	75	75	75	75	75	N/a	50
Safe operating speed	40	40	40	40	40	40	40	40	N/a	100
Pavement type	2	2	2	2	2	2	2	2	N/a	3
Surface type	3	3	3	3	3	3	3	3	N/a	4
Horizontal alignment	1	1	1	1	1	1	1	1	N/a	1
Vertical alignment	1	1	1	1	1	1	1	1	N/a	1
AADT	4000	2000	8000	6000	8000	6000	4000	2000	0	2000
Private	82.0%	88.0%	82.0%	84.0%	82.0%	84.0%	82.0%	88.0%	0.0%	76.0%
Commercial	11.0%	9.0%	11.0%	10.3%	11.0%	10.3%	11.0%	9.0%	0.0%	13.0%
Non-Aortic	3.3%	1.6%	3.3%	2.7%	3.3%	2.7%	3.3%	1.6%	0.0%	5.0%
Buses	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.0%	1.0%
Aortic	1.1%	0.2%	1.1%	0.8%	1.1%	0.8%	1.1%	0.2%	0.0%	2.0%
B-double	1.6%	0.2%	1.6%	1.1%	1.6%	1.1%	1.6%	0.2%	0.0%	3.0%
Rt1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Rt2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Growth rate (% pa linear)	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	N/a	3.0%

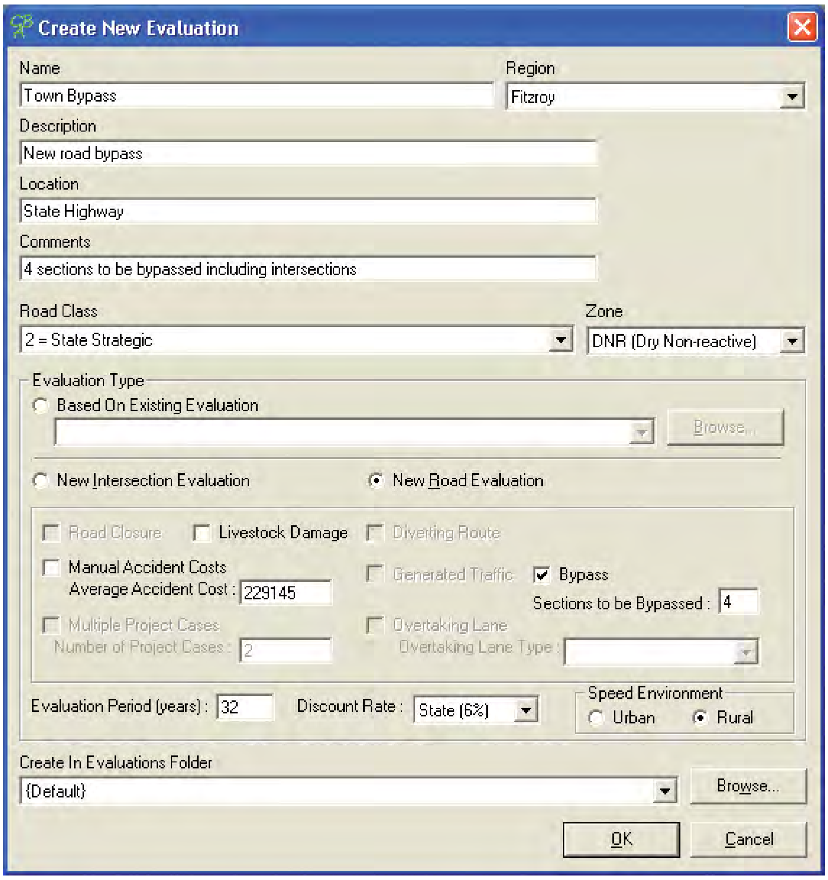
See Section 8.7 of the *Technical Guide* for derivation of AADT calculations.

Note: Bypass costs in the base case are negligible because base case traffic is set to zero (AADT=0).

5.8.2 Create new evaluation

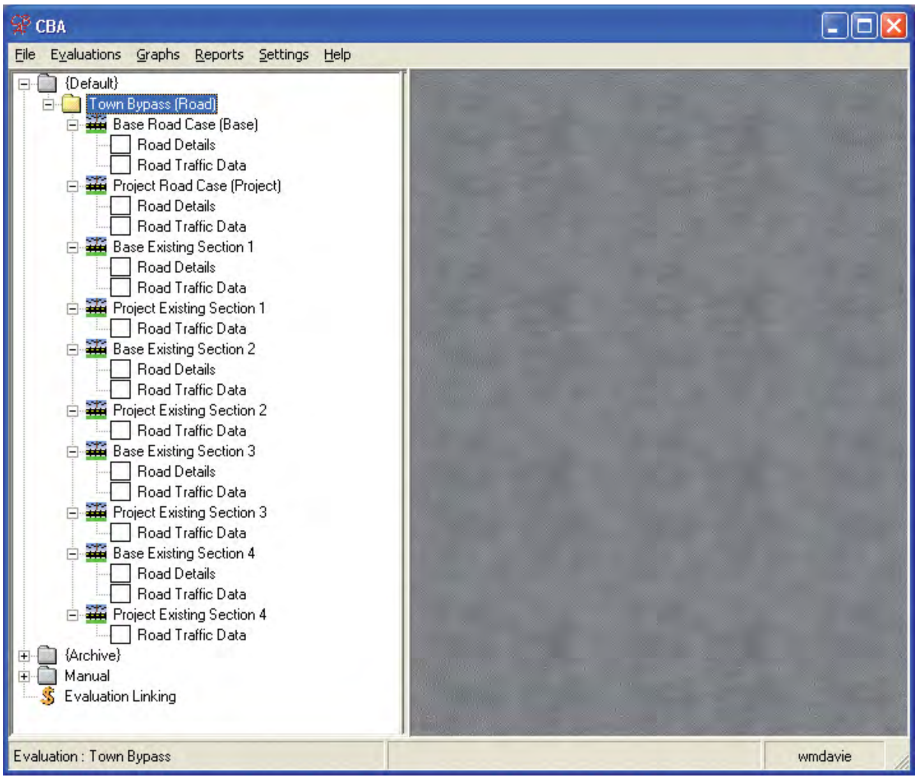
To create a bypass evaluation, the 'bypass' option must be selected. In this case study there will be four sections bypassed. In Figure 148 the bypass box is ticked and '4' has been entered in the 'sections to be bypassed' field.

Figure 148: Bypass evaluation



As shown in Figure 148 the bypass evaluation will have a number of data input fields for the various road sections. The new bypass section in the CBA6 node tree is represented by both the 'base road case' and 'project road case' fields. Section 1 in Figure 147 matches the 'base existing Section 1' from Figure 149**,** with other sections following accordingly.

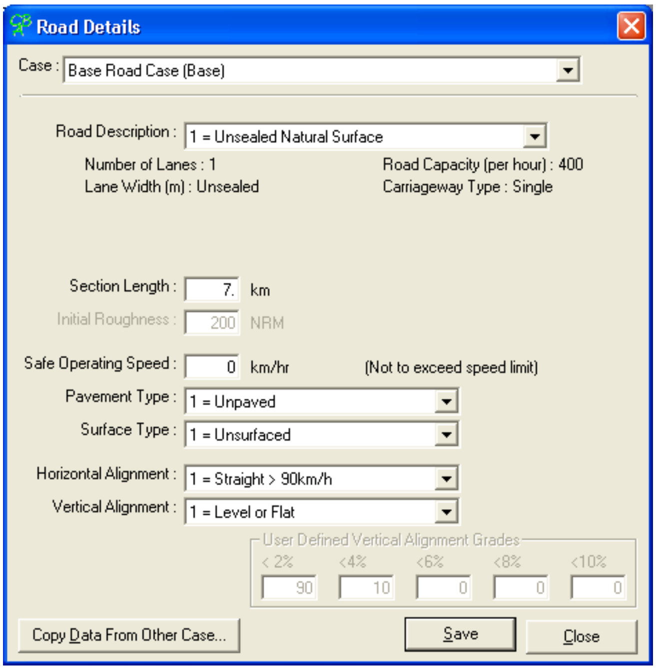
Figure 149: Bypass workspace



5.8.3 Road details

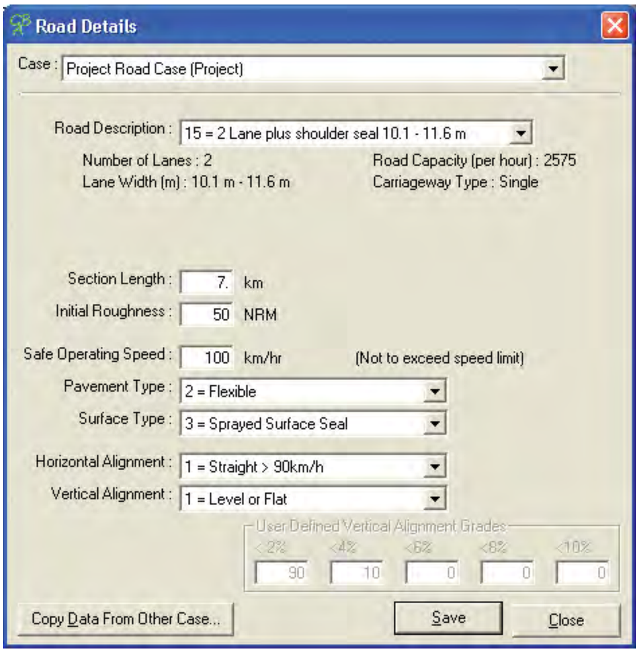
In this case study the bypass will be a newly built road and not an upgrade to an existing route. Therefore, the ‘base road case’ field is superfluous (likewise the ‘road traffic data’ screen will show zero traffic). If this project was an upgrade to an existing road the ‘road details’ screen would need to be correctly completed. For illustrative purposes the base case road details can be entered as shown in Figure 150.

Figure 150: Bypass base case



The proposed bypass (project road case) will be a new two-lane highway. Details for the bypass section are shown in Figure 151.

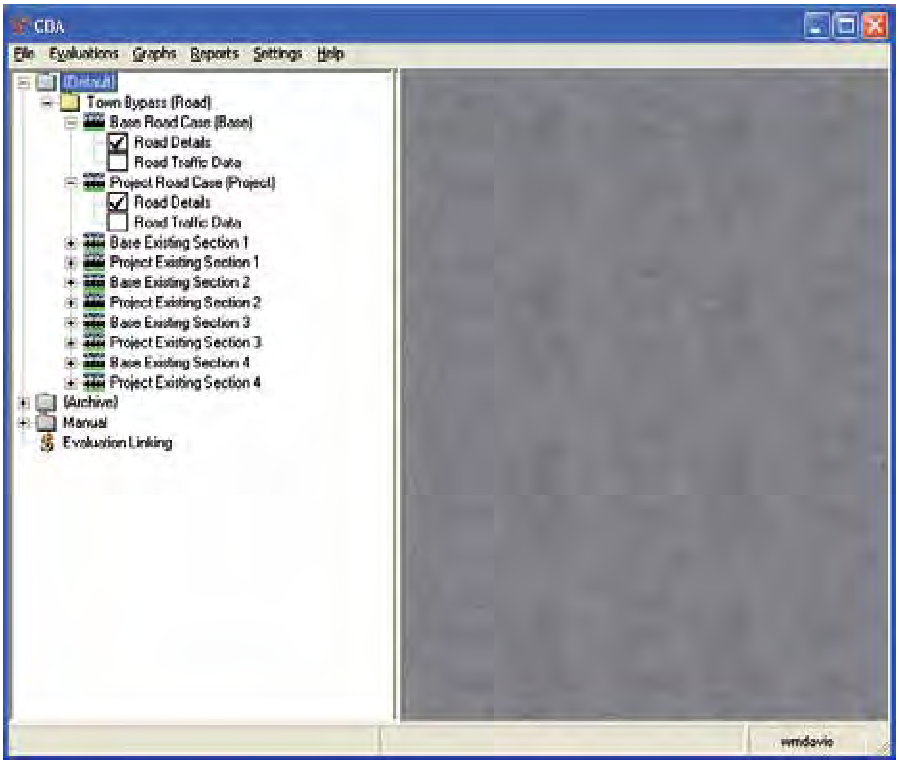
Figure 151: Bypass road details



5.8.4 Road traffic data

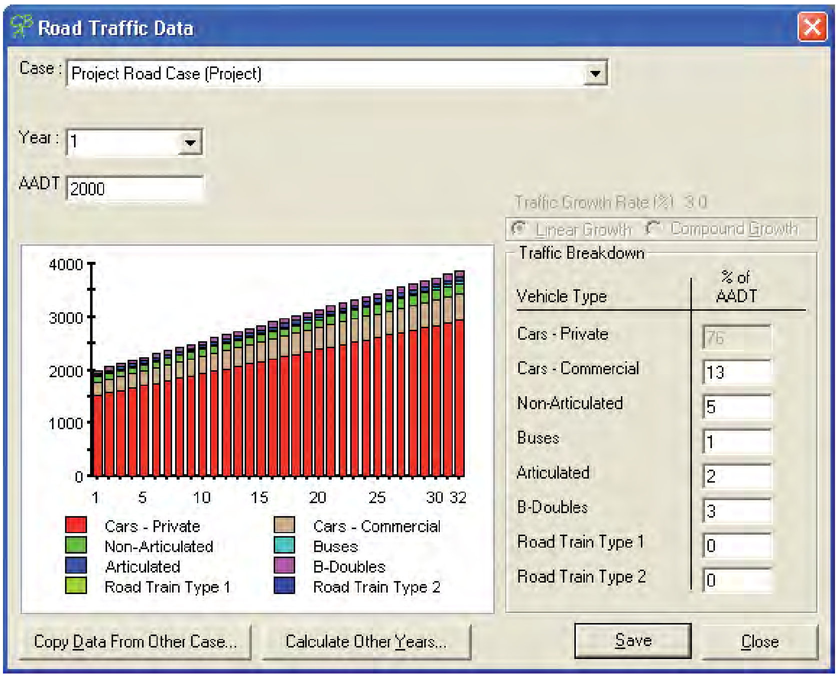
The road traffic data for the bypass is the next input field, see Figure 152.

Figure 152: Bypass road traffic data workspace



Here the system user is now required to enter the traffic that will divert from the old highway to the new bypass. In Table 5, the breakdown of traffic for the bypass is shown. 2000 vehicles per day will use the new bypass, see Figure 153.

Figure 153: Traffic on bypass

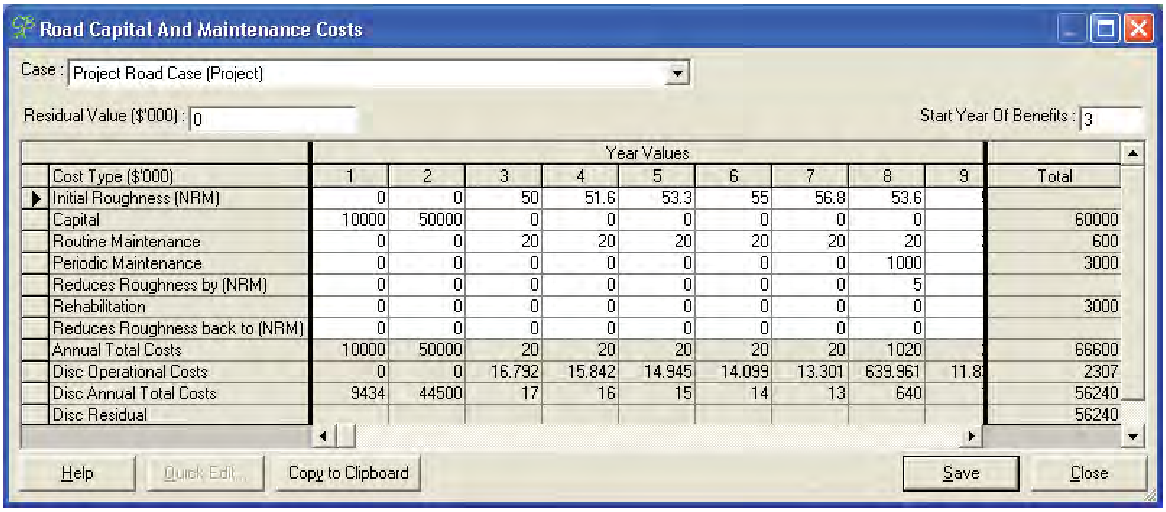


Note: In the base case traffic data screen, 0 must be entered for all years of the evaluation.

5.8.5 Capital and maintenance costs

The 'capital and maintenance costs' screen refers to the bypass section only. In the base case maintenance will be $50 000. Roughness deterioration is not calculated in CBA6 for the existing route within the bypass module. The cost to build the new bypass is estimated at $60 million. The new bypass will be resealed every seven years, starting from Year 8 at a cost of $1 million for each reseal with the exception of Year 22. Figure 154 shows the cost forecast for the project.

Figure 154: Bypass costs



Road Capital And Maintenance Costs

Case : Project Road Case (Project)

Residual Value ($'000) : 0

Start Year Of Benefits : 3

	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	0	50	51.6	53.3	55	56.8	53.6		
Capital	10000	50000	0	0	0	0	0	0		60000
Routine Maintenance	0	0	20	20	20	20	20	20		600
Periodic Maintenance	0	0	0	0	0	0	0	1000		3000
Reduces Roughness by (NRM)	0	0	0	0	0	0	0	5		
Rehabilitation	0	0	0	0	0	0	0	0		3000
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	10000	50000	20	20	20	20	20	1020		66600
Disc Operational Costs	0	0	16.792	15.842	14.945	14.099	13.301	639.961	11.8	2307
Disc Annual Total Costs	9434	44500	17	16	15	14	13	640		56240
Disc Residual										56240

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Note: The system user is not required to enter maintenance data for the four existing routes. Maintenance costs for the existing routes are not expected to change between the base and project cases. As a result, the roughness measure on the existing routes will not change between the base and project cases, therefore the net result will be zero.

5.8.6 Accident and other costs

Accident costs will be automatically calculated by CBA6. The accident rate on the existing routes will decline due to reduced traffic after the bypass is completed. The accident rate on the new bypass will increase from zero before the bypass is constructed to a positive accident rate after it is opened to traffic. The net result should be an overall reduction in accidents as the bypass is a shorter length compared with the existing routes.

Note: Other costs and benefits relevant to a bypass evaluation may include a reduction in externalities such as noise levels on the existing route, as highway traffic now bypasses local roads and residents. See Section 7 of the *Technical Guide* for further information on calculation of these costs and benefits.

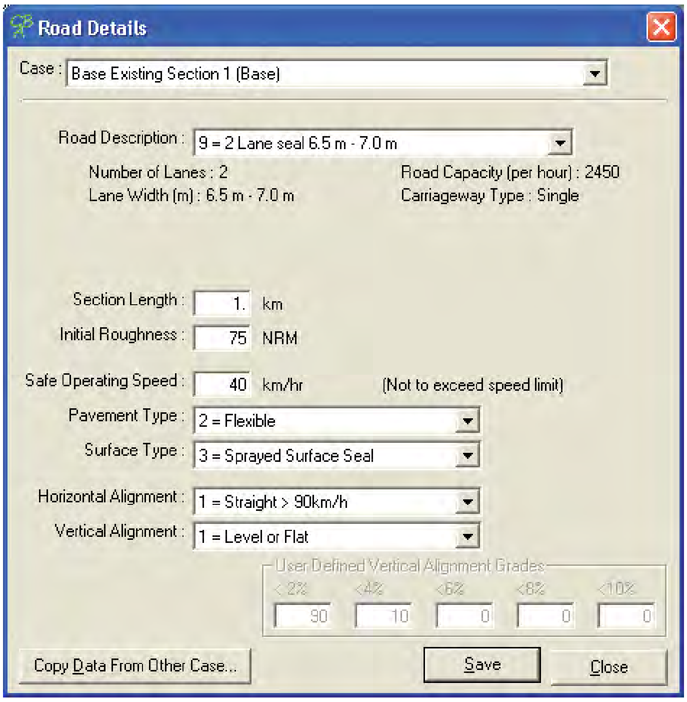
5.8.7 Existing sections

The next step after the bypass section details have been completed is to input the data for the existing road sections. The road details and traffic input data for each existing section is shown in Table 6. The input screens for the existing road sections are the same as for previous case studies. With the provision of the bypass, it is assumed that 2000 vehicles will choose to travel along the upgrade (higher throughput and reduced travel cost), while the remaining road users travel along the existing sections (local road users). These 'switching' vehicles are represented in the project case of the bypass in Figure 147.

5.8.7.1 Existing Section 1

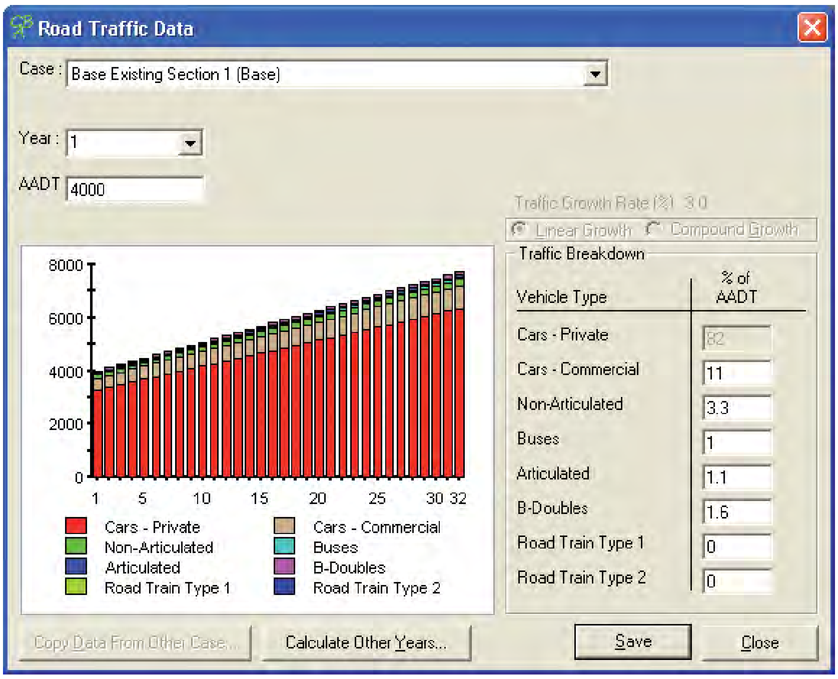
Road details for Section 1 are shown in Figure 155.

Figure 155: Existing Section 1 road details



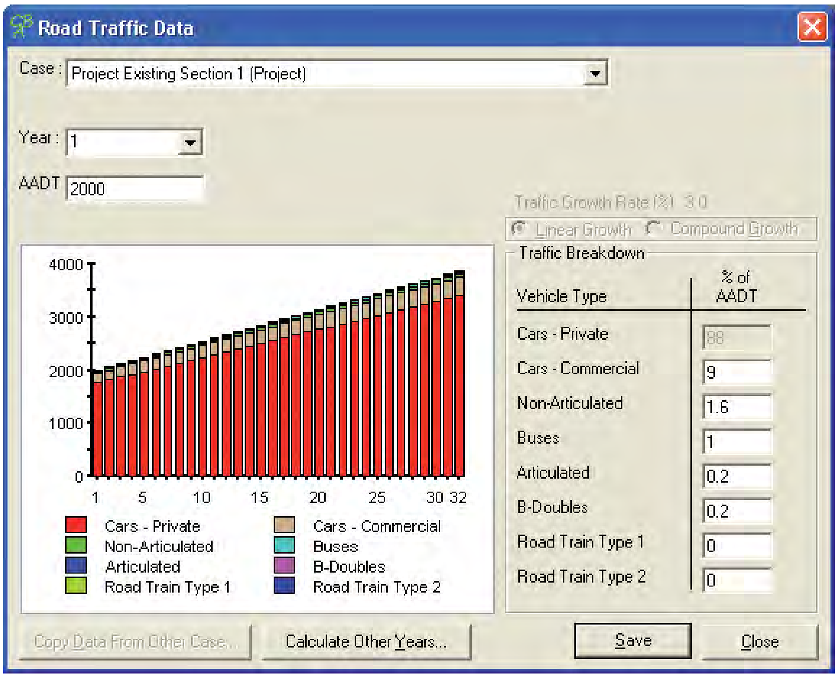
Traffic data for the existing Section 1 in the base case is shown in Figure 156. An estimated average of 4000 vehicles travel on this section every day.

Figure 156: Existing Section 1 base case traffic



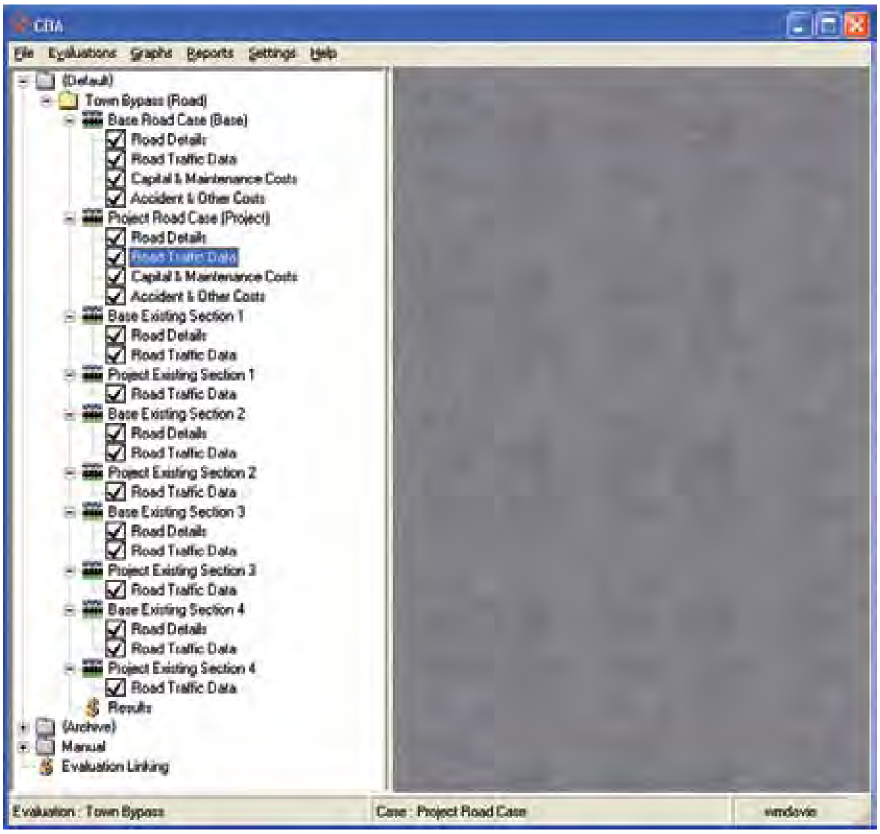
After the bypass is built, only 2000 vehicles per day will travel on Section 1, see Figure 157.

Figure 157: Existing Section 1 project case traffic



After all input data has been saved, the results of the bypass evaluation can be calculated, see Figure 158.

Figure 158: Town bypass workspace



5.8.8 Results and decision criteria

The new $60 million bypass provides a BCR of 1.44 at the 6% discount rate, see Figure 159. The majority of benefits comprise savings in journey time. In the base case, the average speed through the town was 40 km/h which incorporated delays at intersections. The new bypass enables highway traffic to travel at 100 km/h. Commercial vehicles are estimated to gain over $22 million in TTC savings, which satisfies the project objective to better cater for business travel. Around 10% of the project benefits relate to the reduction in accidents through the town. See Section 2.4.3 of the *Theoretical Guide* for more information on bypass evaluations.

Figure 159: Bypass results

Results - Decision Criteria Recalc No 7

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	58,141,739	55,536,345	54,364,331	53,262,145	51,230,198
Discounted Capital Costs	55,843,195	53,933,784	53,017,731	52,126,200	50,413,223
Discounted Other Costs	2,298,544	1,602,560	1,346,600	1,135,944	816,975
Discounted Benefits	107,990,809	80,232,409	69,957,944	61,438,312	48,337,804
Private TTC Savings	43,772,571	32,623,493	28,487,975	25,054,042	19,763,163
Commercial TTC Savings	30,799,088	22,957,177	20,048,376	17,633,023	13,911,421
Private VOC Savings	11,824,399	8,649,728	7,486,205	6,527,630	5,067,540
Commercial VOC Savings	10,459,999	7,703,333	6,688,692	5,850,434	4,568,378
Discounted Accident Savings	11,134,752	8,298,679	7,246,696	6,373,182	5,027,301
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	49,849,070	24,696,064	15,593,613	8,176,167	-2,892,394
Net Present Value per dollar Investment	0.89	0.46	0.29	0.16	-0.06
Benefit Cost Ratio Excl. Private Time	1.10	0.86	0.76	0.68	0.56
Benefit Cost Ratio	1.86	1.44	1.29	1.15	0.94
First Year Rate of Return	7.84%	7.67%	7.58%	7.50%	7.34%

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Note: For further information on the calculation of bypass benefits, see Section 8.7 of the *Technical Guide*.

5.9 Unsealed roads

A large proportion of Queensland's road network comprises unsealed roads; some of these roads have been designated as development roads. Unsealed roads often suffer from corrugation and other surface defects which impact negatively on vehicle ride, speed and safety. Progressively upgrading these roads by sealing the surface will therefore significantly reduce VOC savings and TTC savings. CBA6 values the benefits of road sealing initiatives and also calculates the benefits to livestock transport. Refer to Section 8.6 of the *Technical Guide* for details of livestock calculations.

The primary economic benefits from sealing roads are derived from the reduction in damage to livestock. Other benefits include access to remote areas, especially during the wet season. Rain and flooding can destroy unsealed roads which then require significant costs to rehabilitate. In these instances, a sealed road will have smaller maintenance costs than an unsealed road.

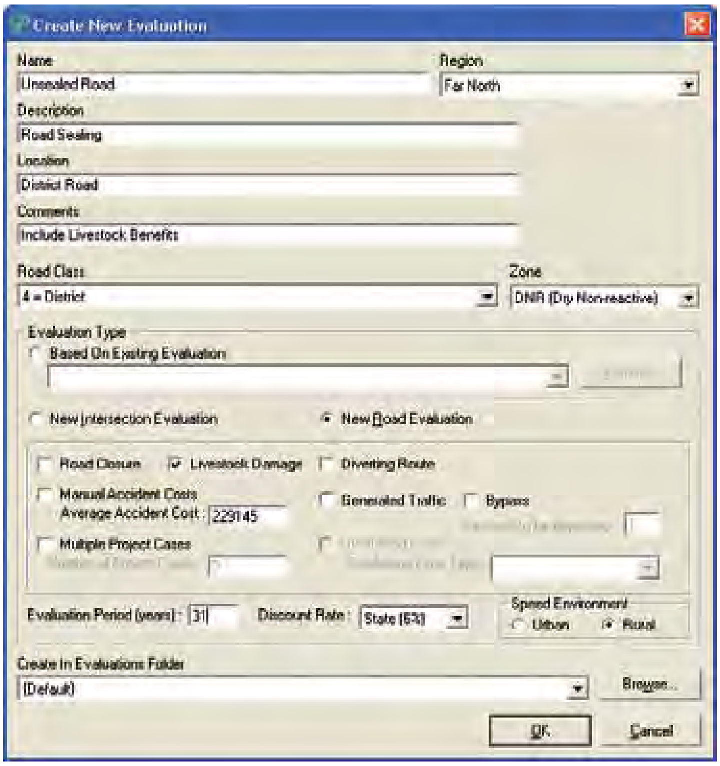
5.9.1 Unsealed road case study

For this case study, it is assumed that connectivity between two remote communities is provided via a 12 km section of unsealed developmental road. The road is not subject to flooding. Sealing the road will provide a better road surface and improved access. This region is reliant on primary production, and consequently there is a high proportion of road train livestock freight in the current vehicle fleet. The AADT for the development road is 125 vehicles per day, 17% of which are road trains. The project will provide a sprayed seal surface with construction occurring over one year at a cost of $6 million.

5.9.2 Create new evaluation

This project will benefit livestock operators using the new sealed road. See Section 2.4.4 of the *Theoretical Guide* for further information on livestock impacts. The 'livestock damage' option is ticked as seen in Figure 160. Not all road sealing projects will have livestock benefits. This option should only be used when appropriate.

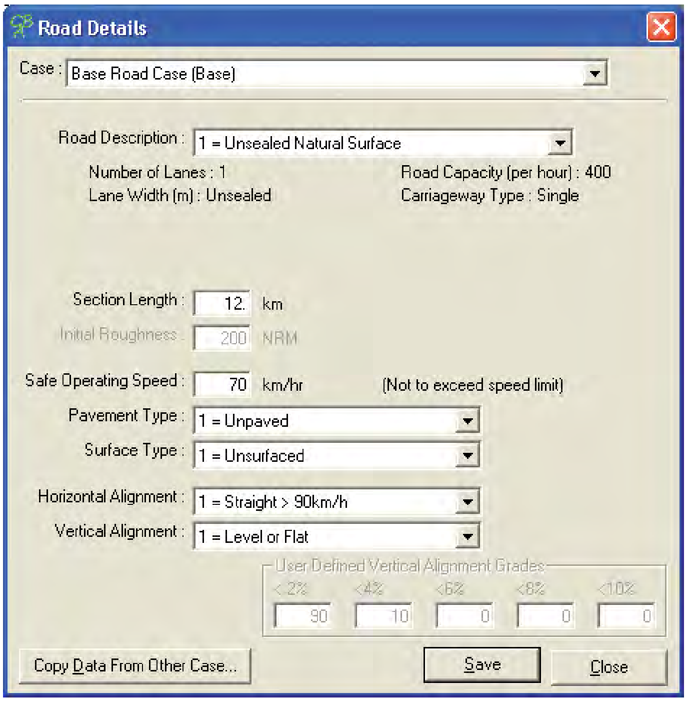
Figure 160: Unsealed road evaluation



Note: When the livestock damage option is selected, CBA6 will automatically assign the apprioriate options of MRS available for the base case.

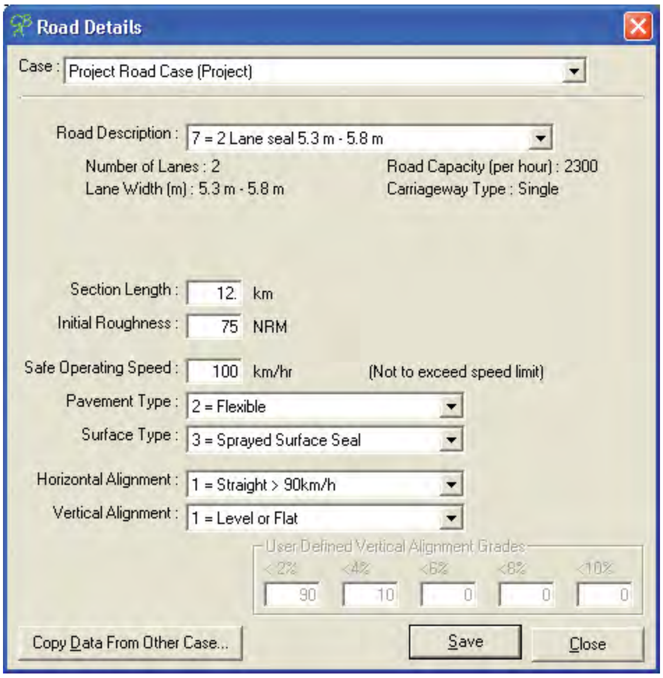
5.9.3 Road details

Figure 161: Unsealed road in the base case



The project case will provide a new sprayed surface road. Details for the project case are shown in Figure 162. The improved road surface enables an increase in the safe operating speed.

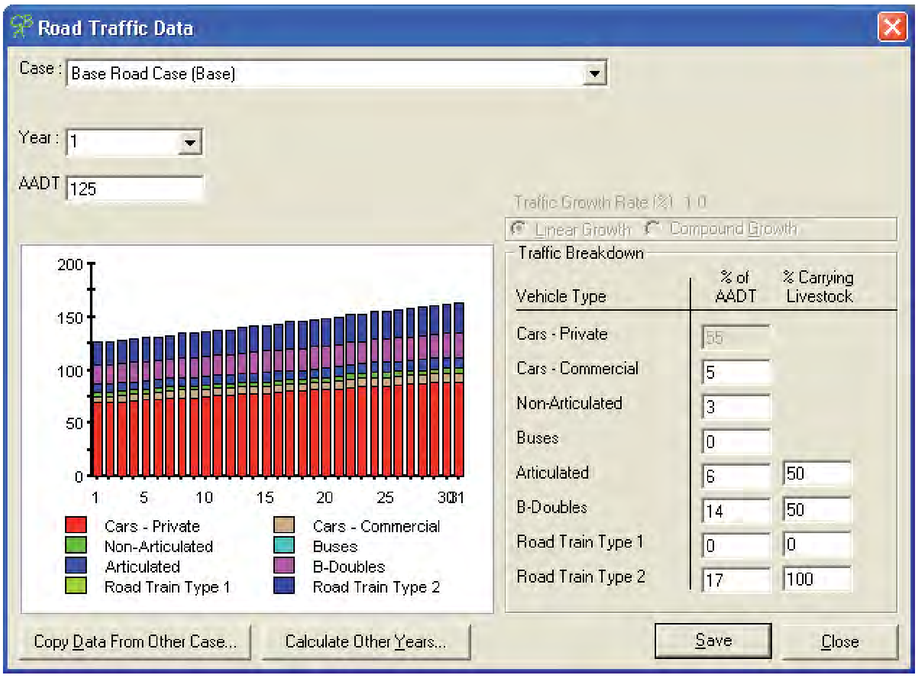
Figure 162: Sealed project case



5.9.4 Road traffic data

The ‘road traffic data’ screen for road sealing projects is different from other case studies. CBA6 requires data on the proportion of heavy vehicles carrying livestock. The base case traffic data is shown in Figure 163. It is assumed that all road trains carry livestock while only half of the articulated and B-double vehicles transport livestock. Annual traffic growth is 1% linear and traffic data will remain the same between the base and project cases.

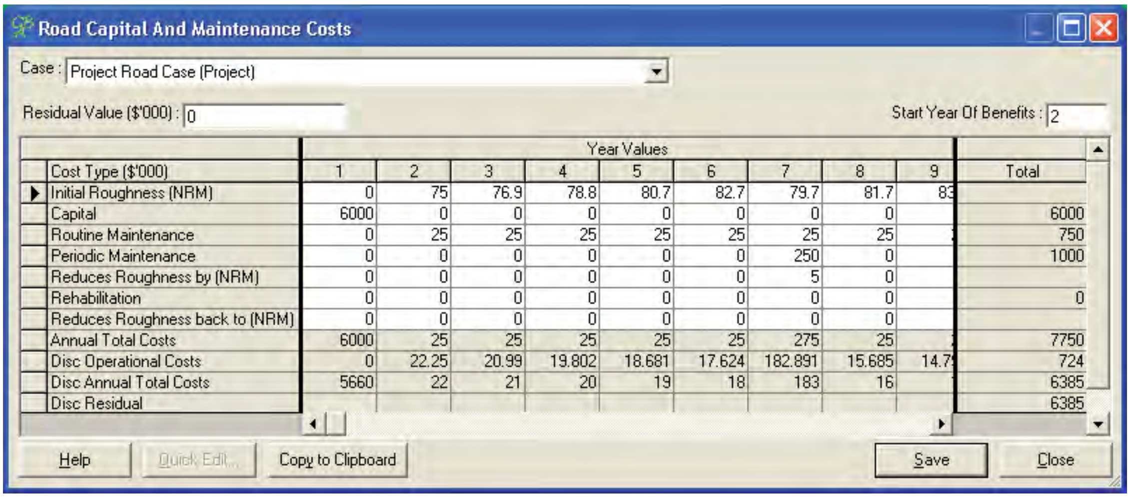
Figure 163: Unsealed road traffic data with livestock



5.9.5 Capital and maintenance costs

Routine maintenance costs in the base case are $20 000 per year. The estimated capital cost for the project is $6 million with routine maintenance of $25 000 per year. Periodic maintenance will occur every 7 years which will reduce roughness by 5 NRM. Project case costs are shown in Figure 164.

Figure 164: Sealed road costs



	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	75	76.9	78.8	80.7	82.7	79.7	81.7	83	
Capital	6000	0	0	0	0	0	0	0		6000
Routine Maintenance	0	25	25	25	25	25	25	25		750
Periodic Maintenance	0	0	0	0	0	0	250	0		1000
Reduces Roughness by (NRM)	0	0	0	0	0	0	5	0		
Rehabilitation	0	0	0	0	0	0	0	0		0
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	6000	25	25	25	25	25	275	25		7750
Disc Operational Costs	0	22.25	20.99	19.802	18.681	17.624	182.891	15.685	14.7	724
Disc Annual Total Costs	5660	22	21	20	19	18	183	16		6385
Disc Residual										6385

5.9.6 Accident and other costs

Accident costs are calculated automatically by CBA6 in the base and project cases. As the primary aim of this project is to seal an unsealed road, accident cost savings do not comprise a major benefit.

5.9.7 Results and decision criteria

The sealed road project has a BCR of 1.32 at the 6% discount rate. The FYRR is high at 8.6% indicating that the project need not be delayed.

The majority of project benefits accrue from savings in VOC for commercial vehicles. This is not surprising given the condition of an unsealed road. A new sealed road will provide a much smoother ride for freight vehicles. There are also significant livestock benefits for transport operators with savings of around $1.8 million in livestock damage costs.

Figure 165: Sealed road results

Results - Decision Criteria Recalc No 7

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	6,360,561	6,105,724	5,997,392	5,898,787	5,724,454
Discounted Capital Costs	5,769,231	5,660,377	5,607,477	5,555,556	5,454,545
Discounted Other Costs	591,330	445,346	389,915	343,231	269,909
Discounted Benefits	10,339,479	8,008,214	7,124,009	6,379,377	5,208,772
Private TTC Savings	476,683	369,071	328,237	293,842	239,766
Commercial TTC Savings	1,274,237	994,320	887,481	797,152	654,376
Private VOC Savings	868,066	671,742	597,360	534,757	436,417
Commercial VOC Savings	6,009,506	4,652,044	4,137,432	3,704,179	3,023,353
Discounted Accident Savings	-620,857	-479,358	-425,822	-380,807	-310,199
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	2,331,844	1,800,394	1,599,321	1,430,253	1,165,058
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	3,978,919	1,902,490	1,126,617	480,590	-515,682
Net Present Value per dollar Investment	0.69	0.34	0.20	0.09	-0.09
Benefit Cost Ratio Excl. Private Time	1.55	1.25	1.13	1.03	0.87
Benefit Cost Ratio	1.63	1.31	1.19	1.08	0.91
First Year Rate of Return	8.73%	8.57%	8.49%	8.41%	8.26%

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Note: The ‘discounted accident savings’ row shows disbenefits for accidents. This implies that there will be an increase in accidents in the project case. CBA6 uses data from around the state to determine the accident rate for certain road types to form a representative state average. In this example, the accident frequency of an MRS 1 is less than on an MRS 7. As with every case study, if site specific data exists, the system user should manually calculate accident costs by selecting the ‘manual accident cost’ option in the ‘create new evaluation’ screen.

5.10 Generated traffic

AADT is normally the same for both the base and project cases. Generated traffic is managed as a separate node and is the additional number of trips expected to be made by road users in response to perceived reductions in costs from a proposed road project initiative. The extent of generated traffic depends upon the sensitivity of road travel to a change in the perceived costs of road travel along a particular route.

CBA6 calculates generated traffic benefits by estimating the increase in consumer surplus attributed to the upgrade. This method of deriving generated traffic benefits is referred to as the 'rule of half' as the gain in the consumer surplus forms a triangle. For more information on generated traffic, see Section 2.4.2 of the *Theoretical Guide*.

5.10.1 Generated traffic case study

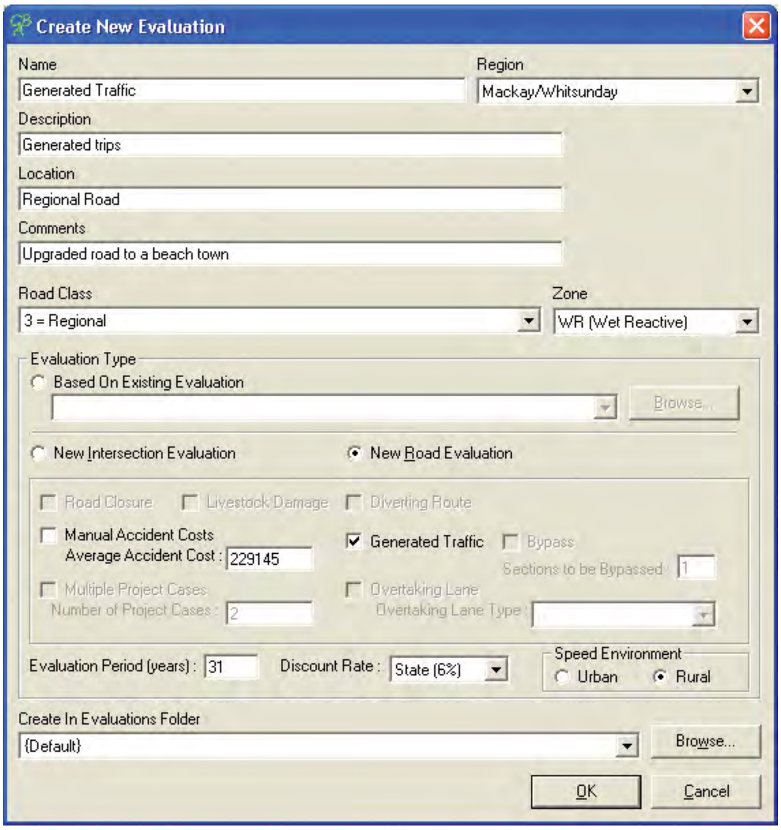
This case study will show a simplified example of generated traffic. In this example, access to a coastal community is only available by a poorly designed narrow road. The condition of the current road results in a slow trip to the community from the main highway. Economic growth is constricted due to lack of proper access. TMR proposes a significant upgrade to the existing road. The new road is anticipated to generate an additional 150 trips per day in the first year of opening. Savings in TTC is the main reason for increased demand in road traffic.

Note: CBA6 only calculates benefits to road users and assumes that the savings in road user costs will be passed on to the community. Therefore additional benefits are implicitly calculated through TTC savings and VOC savings. Additional flow-on effects beyond these benefits should be calculated by an economist.

5.10.2 Create new evaluation

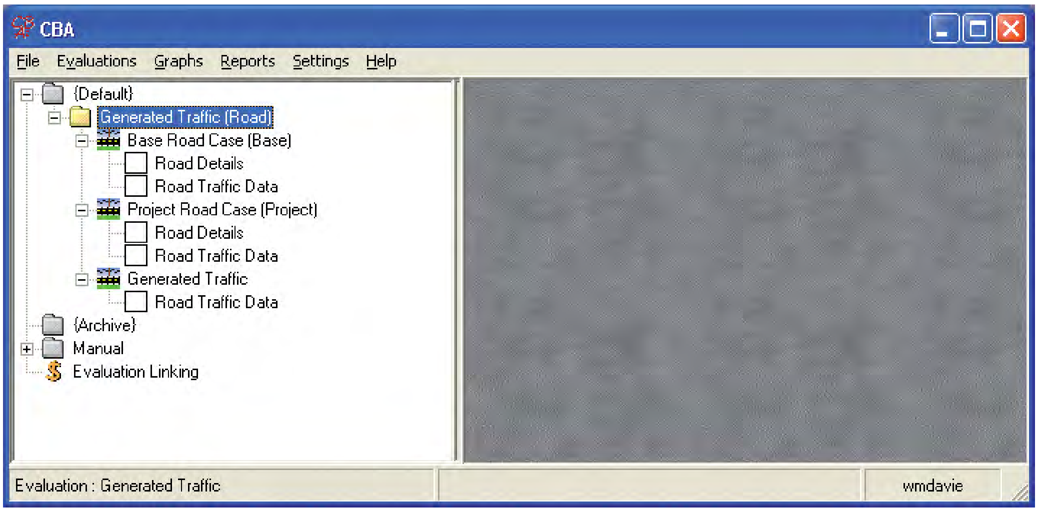
To create a generated traffic evaluation the 'generated traffic' option must be selected as shown in Figure 166.

Figure 166: Generated traffic evaluation



The generated traffic node tree is different to other case studies, see Figure 167. The 'generated traffic' data screen requires the system user to enter the estimated number of increased trips made per day.

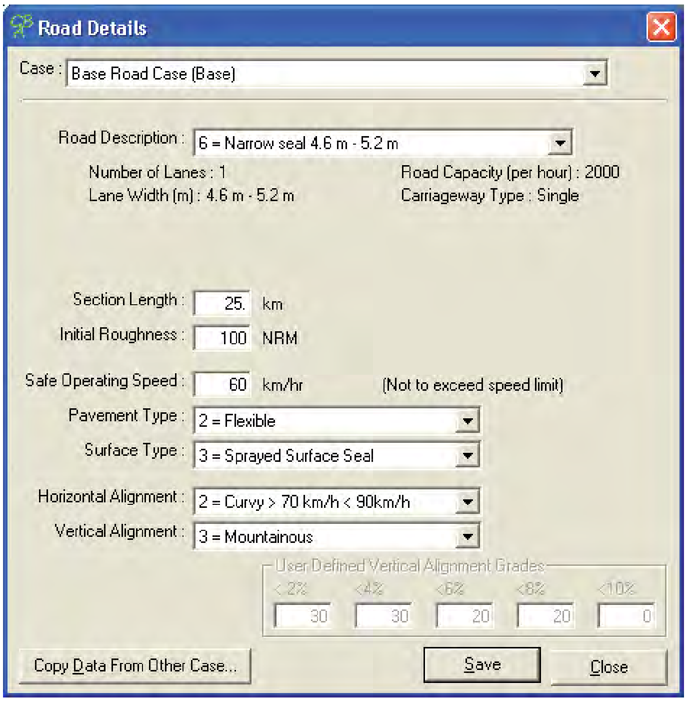
Figure 167: Generated traffic workspace



5.10.3 Road details

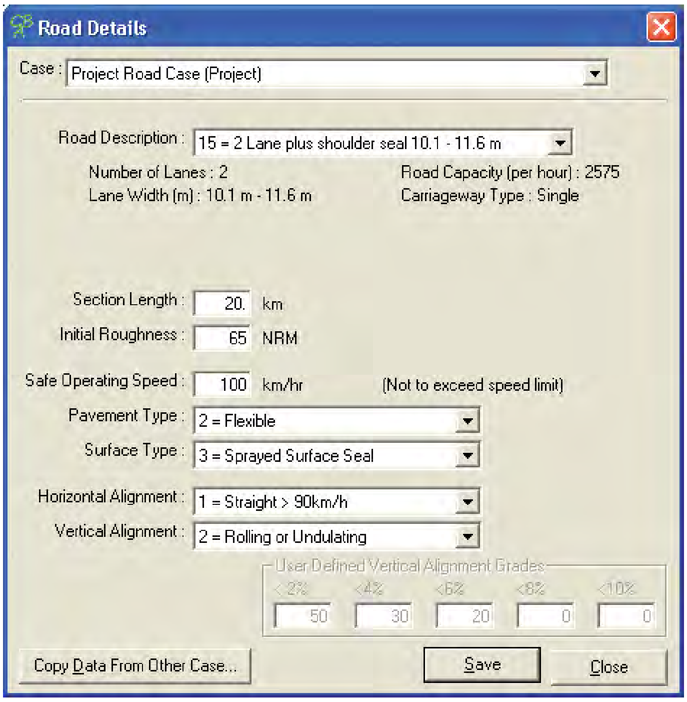
The road details for the current road are shown in Figure 168. The base case is a narrow road with poor horizontal and vertical alignment.

Figure 168: Base case road to coastal town



The new road will provide a safer alignment which reduces the length of the journey. With a safer horizontal alignment, the speed limit is increased to 100 km/h. The realignment of the old road reduces the journey length for road users. This will stimulate additional demand for the road. Project case road details are shown in Figure 169.

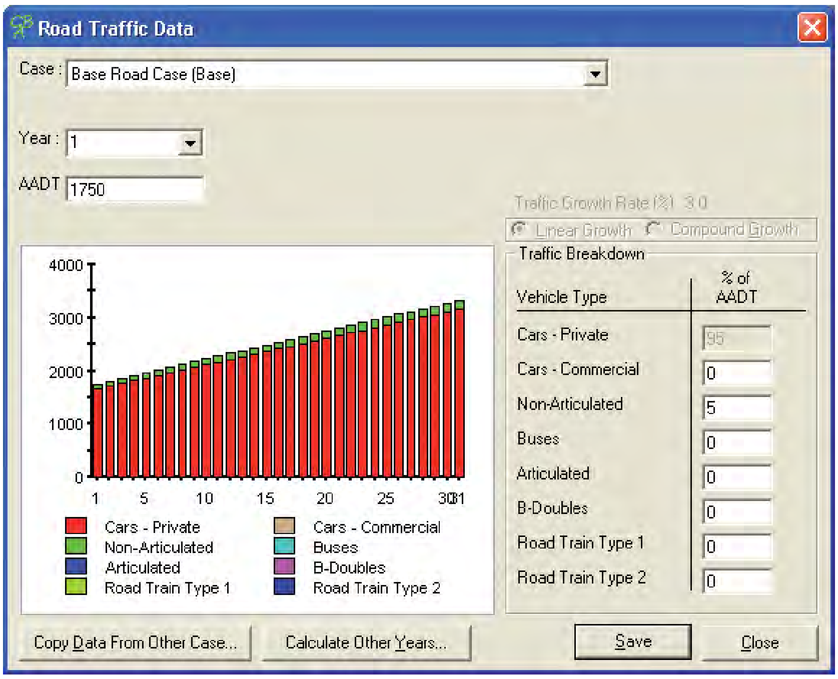
Figure 169: Project case road details



5.10.4 Road traffic data

The 'road traffic data' screen is used to specify existing traffic demand, therefore the base and project cases traffic data remain the same. The additional trips made when the project is complete will be entered in the 'generated traffic' node. Existing traffic demand is shown in Figure 170.

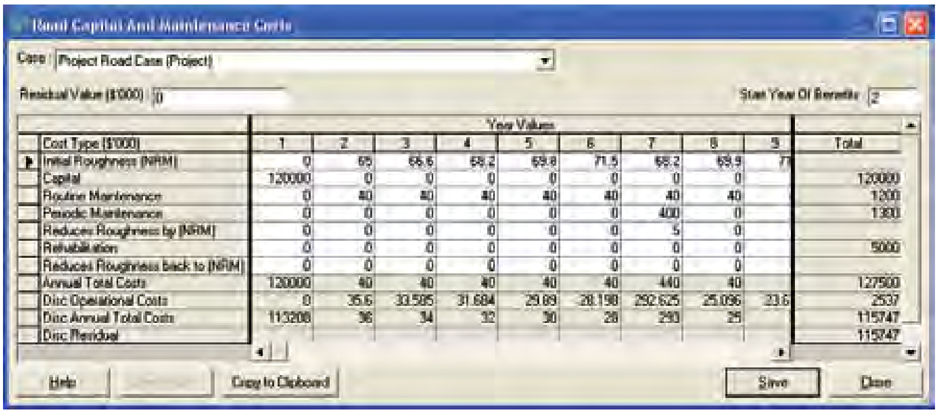
Figure 170: Existing traffic demand



5.10.5 Capital and maintenance costs

Base case routine maintenance costs are $50 000 per year. Routine maintenance in the project case is estimated at only $40 000 per year. This is due to the shorter road length. The estimated capital cost for the project is $120 million with periodic maintenance of $400 000 for Years 7, 14 and 28. Periodic maintenance will reduce roughness by 5 NRM. Rehabilitation of the new road will occur in Year 21 costing $5 million. This will reduce roughness to a level of 70 NRM. Figure 171 shows the project case costs. Base case costs can be found in Appendix A.

Figure 171: New road costs



Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	65	66.6	68.2	69.8	71.5	68.2	69.9	7	
Capital	120000	0	0	0	0	0	0	0		120000
Routine Maintenance	0	40	40	40	40	40	40	40		1200
Periodic Maintenance	0	0	0	0	0	0	400	0		1300
Reduces Roughness by (NRM)	0	0	0	0	0	0	5	0		
Rehabilitation	0	0	0	0	0	0	0	0		5000
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	120000	40	40	40	40	40	440	40		127500
Disc Operational Costs	0	35.6	33.505	31.684	29.89	28.198	292.625	25.096	23.6	2537
Disc Annual Total Costs	113208	36	34	32	30	28	293	25		115747
Disc Residual										115747

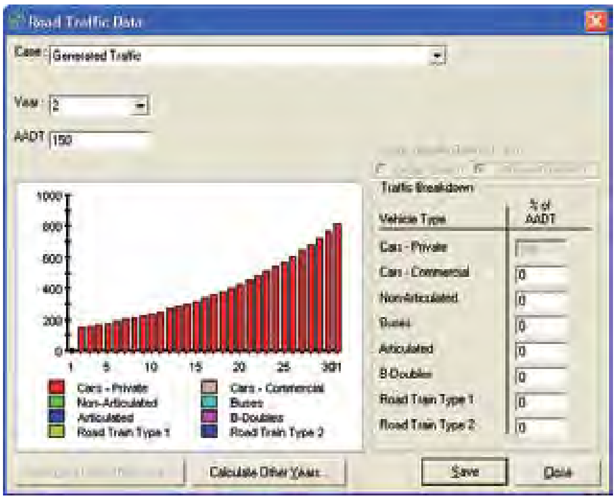
5.10.6 Accident and other costs

Accident costs will be automatically calculated by CBA6. These costs should reduce in the project case given the reduction in the distance road users have to travel, and the improvement in the model road state.

5.10.7 Generated traffic

It is anticipated that the new road will generate an additional 150 trips by private commuters. Demand is expected to increase each year at 6% from Year 2 (first year of operation). Figure 172 shows the generated traffic demand for the new road. In this example, compound growth has been used to simulate the increasing growth each year. The decrease in travel time to the coastal town is the main reason for increased demand for the road.

Figure 172: Generated traffic



5.10.8 Results and decision criteria

The new road provides significant TTC savings and VOC savings to existing traffic. Road users who had previously used the old road in the base case, now receive TTC savings of $46 million at the 6% discount rate. The project BCR is 1.13 and the NPV is positive at $13.9 million, see Figure 173.

The additional benefit which is attributed to those generated trips using the new road is $5.3 million. By improving access to the coastal community and thereby lowering road user costs, the project generated an additional 4% worth of economic benefits (generated benefits as a proportion of total benefits).

Figure 173: Generated traffic results

Results - Decision Criteria Recalc No 22

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	112,603,563	110,912,329	110,064,744	109,217,105	107,525,571
Discounted Capital Costs	115,384,615	113,207,547	112,149,533	111,111,111	109,090,909
Discounted Other Costs	-2,781,053	-2,295,218	-2,084,789	-1,894,006	-1,565,338
Discounted Benefits	164,557,161	124,833,247	109,968,998	97,560,465	78,300,352
Private TTC Savings	58,230,257	44,221,381	38,975,172	34,593,520	27,787,846
Commercial TTC Savings	3,445,591	2,625,860	2,317,920	2,060,206	1,658,753
Private VOC Savings	43,088,639	32,854,044	29,011,012	25,795,540	20,787,867
Commercial VOC Savings	8,687,319	6,608,565	5,829,244	5,177,873	4,165,036
Discounted Accident Savings	43,746,490	33,210,711	29,265,720	25,971,182	20,854,836
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	7,358,865	5,312,685	4,569,930	3,962,144	3,046,013
Net Present Value (NPV)	51,953,598	13,920,918	-95,746	-11,656,639	-29,225,219
Net Present Value per dollar Investment	0.45	0.12	0.00	-0.10	-0.27
Benefit Cost Ratio Excl. Private Time	0.94	0.73	0.65	0.58	0.47
Benefit Cost Ratio	1.46	1.13	1.00	0.89	0.73
First Year Rate of Return	5.87%	5.76%	5.71%	5.66%	5.55%

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The generated traffic module has an additional result screen called 'generated traffic benefits', see Figure 174. System users can view this screen to see the yearly flow of generated traffic benefits. In this case study it can be seen that private vehicle generated traffic benefits accrue from Year 2.

Figure 174: Generated traffic benefits

Total Generated Traffic Benefits

VehicleGroup	Year1	Year2	Year3	Year4	Year5	Year6	Year7	Year8	Year9	Year10
Private GTB	0	202,018	214,246	227,160	240,788	255,332	271,014	287,495	304,802	323,020
Cars - Private	0	202,018	214,246	227,160	240,788	255,332	271,014	287,495	304,802	323,020
Commercial GTB	0	0	0	0	0	0	0	0	0	0
Cars - Commercial	0	0	0	0	0	0	0	0	0	0
Non Articulated	0	0	0	0	0	0	0	0	0	0
Buses	0	0	0	0	0	0	0	0	0	0
Articulated	0	0	0	0	0	0	0	0	0	0
B-Doubles	0	0	0	0	0	0	0	0	0	0
Road Train Type 1	0	0	0	0	0	0	0	0	0	0
Road Train Type 2	0	0	0	0	0	0	0	0	0	0
Total GTB	0	202,018	214,246	227,160	240,788	255,332	271,014	287,495	304,802	323,020
Discounted Tot GTB	0	179,795	179,985	179,932	179,931	179,969	180,240	180,378	180,412	180,373

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5.11 Changes in multi-combination vehicle access

Multi-combination vehicles (MCVs) are an increasingly important component of the road transport industry. An MCV is a large vehicle with at least two articulations. Examples include B-doubles and road trains, as well as many new innovative configurations such as B-triples and AAB-quads. For the road transport industry, MCVs can make an important contribution to improving overall industry efficiency.

CBA6 can be used to estimate the economic efficiency gains that arise as more of the network becomes accessible to multi-combination vehicles, including initiatives according to TMR's higher mass limits policy.

This case study explains how to use CBA6 for that purpose. It is important to note that simply redistributing the heavy vehicle composition between vehicle types while retaining the same total heavy vehicle proportion is not a reliable method of estimating the benefits of improved MCV access. The traffic composition data must first be manipulated outside the model.

This case study shows how to manipulate the traffic composition data and then analyse the benefits of improved freight efficiency using CBA6. For more information on freight efficiency, see Section 5.3 of the *Theoretical Guide*.

5.11.1 MCV case study

This case study involves upgrading an existing road to allow access by larger freight vehicles such as road trains. An improved width is required to allow type 2 road trains to operate on this road. In this case study, it is proposed that a section of road is widened to increase road train access from type 1 to type 2.

Table 7 shows the MCV semi-trailer equivalents.

Table 7: Semi trailer equivalents

MCV	Semi – trailer equivalent
B-doubles	1.55 times the payload of a semi-trailer
Type 1 road train	2 times the payload of a semi-trailer
Type 2 road train	3 times the payload of a semi-trailer

Source: TMR (2009).

Table 8 shows how traffic composition will change when the road is opened to type 2 road train access.

Table 8: Change in access

Vehicle type	Base case			Project case			
	AADT	% of total AADT	Semi trailer equivalents	Freight task %	Semi trailer equivalents	AADT	% of total AADT
Private cars	252	48.90%	-	-	-	252	51.35%
Commercial cars	108	21.00%	-	-	-	108	22.01%
Non-Articulated	31	6.00%	-	-	-	31	6.32%
Buses	5	1.00%	-	-	-	5	1.02%
Articiculated	52	10.10%	52	15.00%	27.560959	27.560959	5.62%
B-doubles	5	1.00%	7.739726	5.00%	9.1869863	5.9349558	1.21%
Road trains type 1	62	12.00%	124	40.00%	73.49589	36.747945	7.49%
Road trains type 2	0	0.00%	0	40.00%	73.49589	24.49863	4.99%
Total	515	100.00%	183.73973	100.00%	183.73973	490.74249	100.00%

Note: AADT values are rounded to whole numbers.

In the base case, the road allows for type 1 road trains. Semi-trailer equivalents are used as a proxy for the heavier vehicle types. This results in the calculated load being 183.74 semi-trailers. The values from which the semi-trailer equivalents are calculated are shown in Table 7. As an example, there are 5 B-doubles in the base case. Because a B-double carries 1.55 times the load (in tonnes) of a semi-trailer, the semi-trailer equivalents value is calculated using the formula:

5 B-doubles x 1.55 = 7.75 semi-trailer equivalents

In the project case, the total semi-trailer equivalents of the base case (183.74) has to be shared between the four vehicle types. The first assumption relates to the proportion of the freight task that will be undertaken by each vehicle type. In this example, semi-trailers are assumed to account for 15% of all freight carried by heavy vehicles in the project case.

The formula for estimating the semi-trailer equivalents to be carried by semi-trailers is:

0.15 x 183.74 = 27.56

For B-doubles the calculation in this example is:

0.05 x 183.74 = 9.19

The same calculations are made for type 1 and type 2 road trains, which in this example are each assumed to carry 40% of all heavy freight on the road. At the completion of these calculations, the total semi-trailer equivalents must be the same in the base and project cases (183.74).

Next, convert the semi-trailer equivalents into the actual vehicle composition in the project case. For semi-trailers, the number of vehicles equals the number of semi-trailer equivalents (that is, the conversion factor is one).

To estimate the number of:

- B-doubles, divide semi-trailer equivalents by 1.55
- type 1 road trains, divide semi-trailer equivalents by 2
- type 2 road trains, divide semi-trailer equivalents by 3.

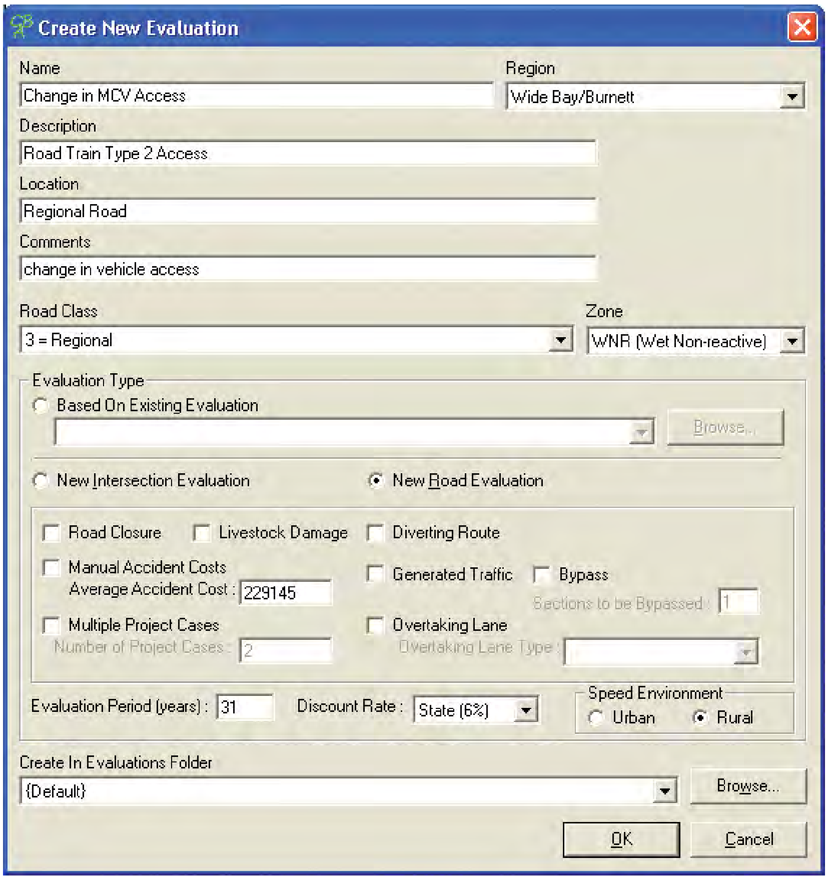
Having completed this conversion, calculate the total project case AADT (494 vehicles in the example), and use this to calculate traffic composition as a percentage of total AADT.

The percentages of total AADT for each vehicle type for base and project cases are entered into the ‘road traffic data’ screen in CBA6. The effect of the increase in road train status is to reduce AADT from the base case to the project case, thereby increasing the benefits.

5.11.2 Create new evaluation

The ‘create new evaluation’ screen for this case study is shown in Figure 175. No advanced modules need to be selected to create a multi-combination vehicle access evaluation.

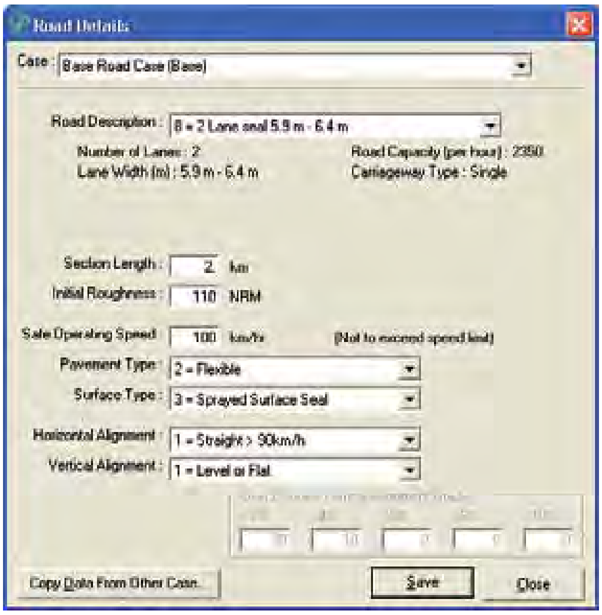
Figure 175: Change in MCV evaluation



5.11.3 Road details

The road details for the current road are shown in Figure 176. The base case is a narrow 5.9 m sealed road that does not allow access for type 2 road trains.

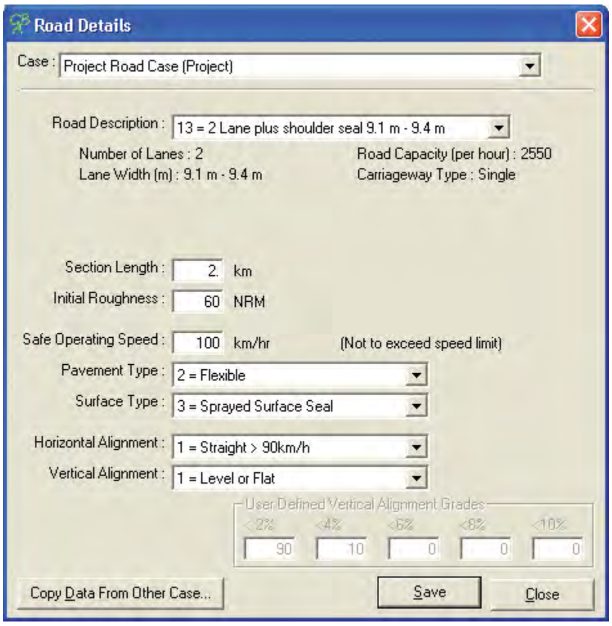
Figure 176: Case case road details with road train access



The new road will provide a wider 9.1 m seal to allow safe access for type 2 road trains. The road details of the project case are shown in Figure 177.

Note: The *Route Assessment Guidelines for Multi-combination Vehicles in Queensland* (DMR 2007) states that for vehicles such as type 2 road trains, the desired seal width should be a minimum of 7 to 9 metres depending on traffic volumes.

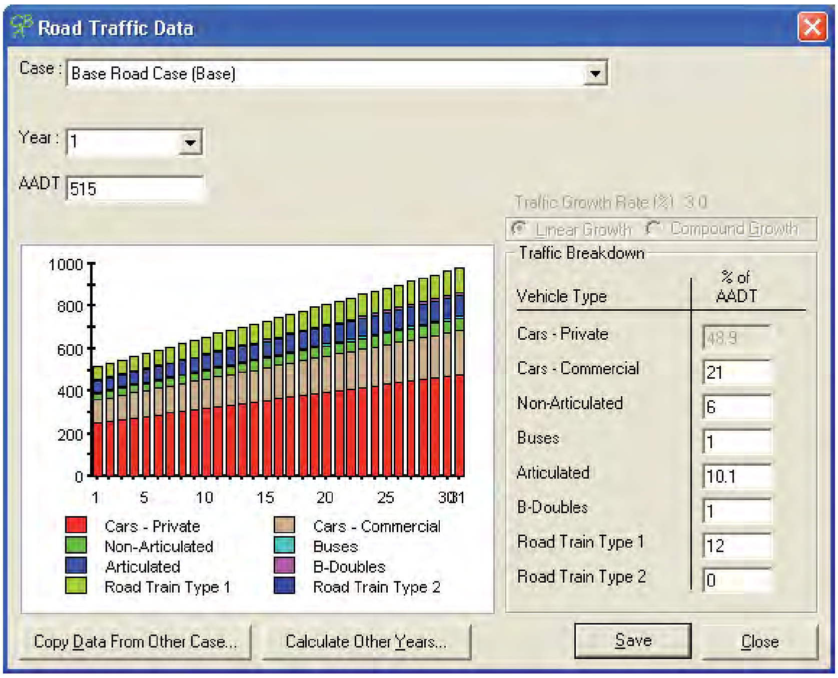
Figure 177: Road details with road train access



5.11.4 Road traffic data

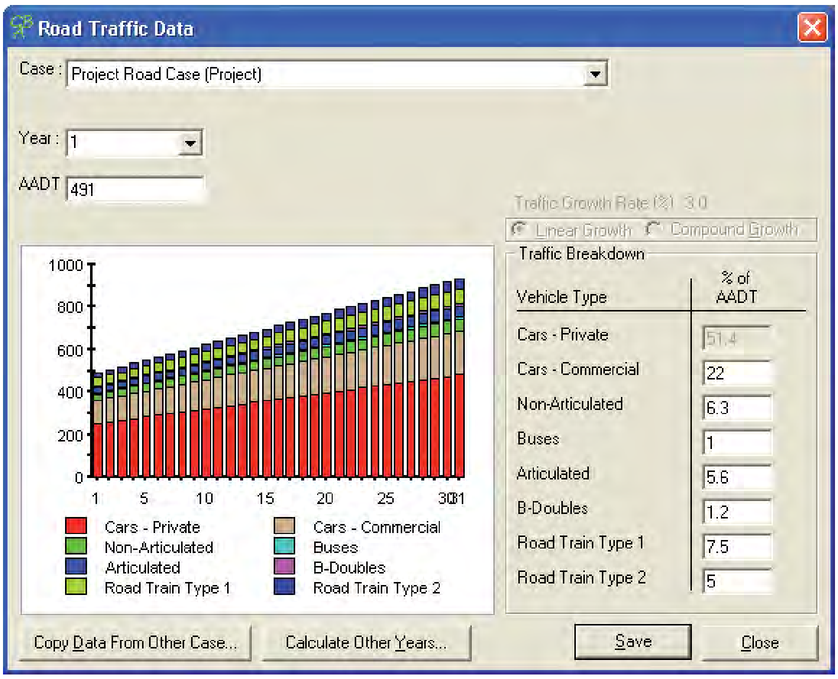
Table 8 provides the traffic composition assumptions for the base and project cases due to the change in vehicle access. The corresponding data for the base case is shown in Figure 178.

Figure 178: Case case traffic without road train type 2



The project case traffic data is shown in Figure 179. Total AADT is lower than in the base case because fewer vehicles are required to undertake the same freight task. A warning message will appear to highlight the differing base and project cases traffic data. As the difference is a consequence of the changed traffic mix, click the 'ok' button.

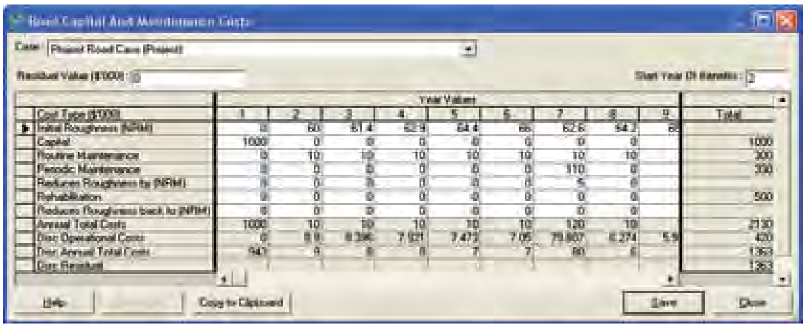
Figure 179: Project case with road train type 2 access



5.11.5 Capital and maintenance costs

Routine maintenance costs in the base case are $5000 per year. Routine maintenance in the project case will increase because of the wider road. The estimated capital cost for the project is $1 million with periodic maintenance of $110 000 for Years 7, 14 and 28. Each periodic maintenance event will reduce roughness by 5 NRM. There will be rehabilitation in Year 21, which will reduce roughness back to 60 NRM. Figure 180 shows the project case costs.

Figure 180: Road train access costs



Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	60	61.4	62.9	64.4	66	62.6	64.2	66	
Capital	1000	0	0	0	0	0	0	0		1000
Routine Maintenance	0	10	10	10	10	10	10	10		300
Periodic Maintenance	0	0	0	0	0	0	110	0		330
Reduces Roughness by (NRM)	0	0	0	0	0	0	5	0		
Rehabilitation	0	0	0	0	0	0	0	0		500
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	1000	10	10	10	10	10	120	10		2130
Disc Operational Costs	0	8.9	8.396	7.921	7.473	7.05	79.807	6.274	5.9	420
Disc Annual Total Costs	943	9	8	8	7	7	80	6		1363
Disc Residual										1363

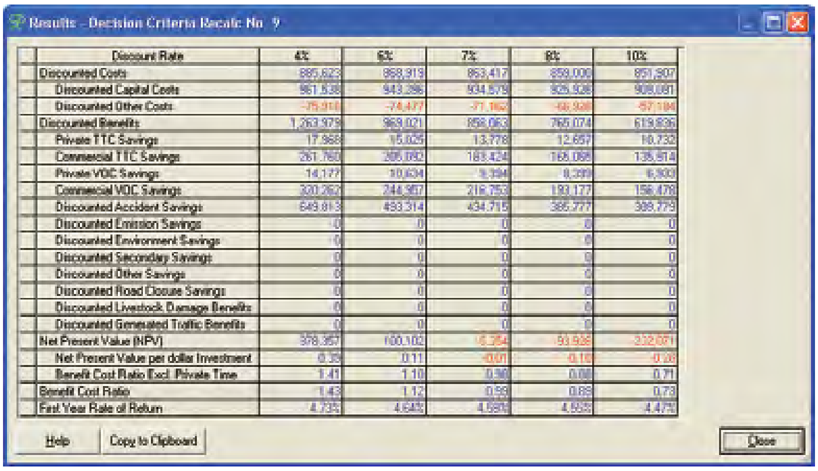
5.11.6 Accident and other costs

Accident costs will be automatically calculated by CBA6. With a wider seal and less traffic, the project case should provide additional accident savings. Similarly, the change in vehicle fleet configuration should result in reductions in vehicle emissions and air pollution, although these changes may be small.

5.11.7 Results and decision criteria

The results of the project are shown in Figure 181. At the 6% discount rate, the project BCR is 1.12 and the NPV is $100 102. The results indicate that the project is economically viable, which is encouraging considering the low traffic volumes on this road. With the change to more efficient vehicles, freight operators will save both time costs and vehicle running costs. The new road also provides an additional safety benefit.

Figure 181: Road train type 2 access results



Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	885,623	868,919	863,417	859,000	851,907
Discounted Capital Costs	961,538	943,396	934,579	925,926	909,091
Discounted Other Costs	-75,914	-74,477	-71,162	-66,926	-57,184
Discounted Benefits	1,263,979	969,021	858,063	765,074	619,836
Private TTC Savings	17,968	15,025	13,778	12,657	10,732
Commercial TTC Savings	261,760	205,082	183,424	165,068	135,814
Private VOC Savings	14,177	10,634	9,394	8,309	6,903
Commercial VOC Savings	320,262	244,967	216,752	193,177	156,478
Discounted Accident Savings	649,813	493,314	434,715	385,777	309,779
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	378,357	100,102	-5,354	-93,926	-232,071
Net Present Value per dollar Investment	0.39	0.11	-0.01	-0.10	-0.26
Benefit Cost Ratio Excl. Private Time	1.41	1.10	0.98	0.88	0.71
Benefit Cost Ratio	1.43	1.12	0.99	0.89	0.73
First Year Rate of Return	4.73%	4.64%	4.59%	4.55%	4.47%

Note: Benefits accrued from this project are from a combination of improved road surface and the change in vehicle fleet. The improved road surface now allows type 2 road trains to use this road. Freight operators will experience both savings in TTC and VOC.

5.12 Multiple project cases

The 'multiple project cases' module in CBA6 is used to compare mutually exclusive project options in order to identify the best option. Options analysis can be defined as a process that identifies alternative solutions that promote or address the same problem. CBA6 is useful in this context where there are alternative treatments that may suitably address a defined transport need. CBA6 compares the incremental benefits and costs of different project options and provides a recommendation on the economically preferred option.

The CBA6 'multiple project cases' module is limited in the scope of project options that can be assessed. For example if there are two project options which require use of other advanced modules in CBA6, these projects will need to be created separately and then linked using the 'incremental analysis' module. Section 5.12 provides an incremental analysis case study using advanced modules in CBA6.

5.12.1 Multiple project case study

This case study involves the evaluation of a rural highway with AADT of 10 000 vehicles per day. The current road is a narrow seal of 5.8 metres and does not adequately cater for current traffic volumes. TMR proposes three options that will provide a better standard highway for road users. Only one of the three options can be implemented.

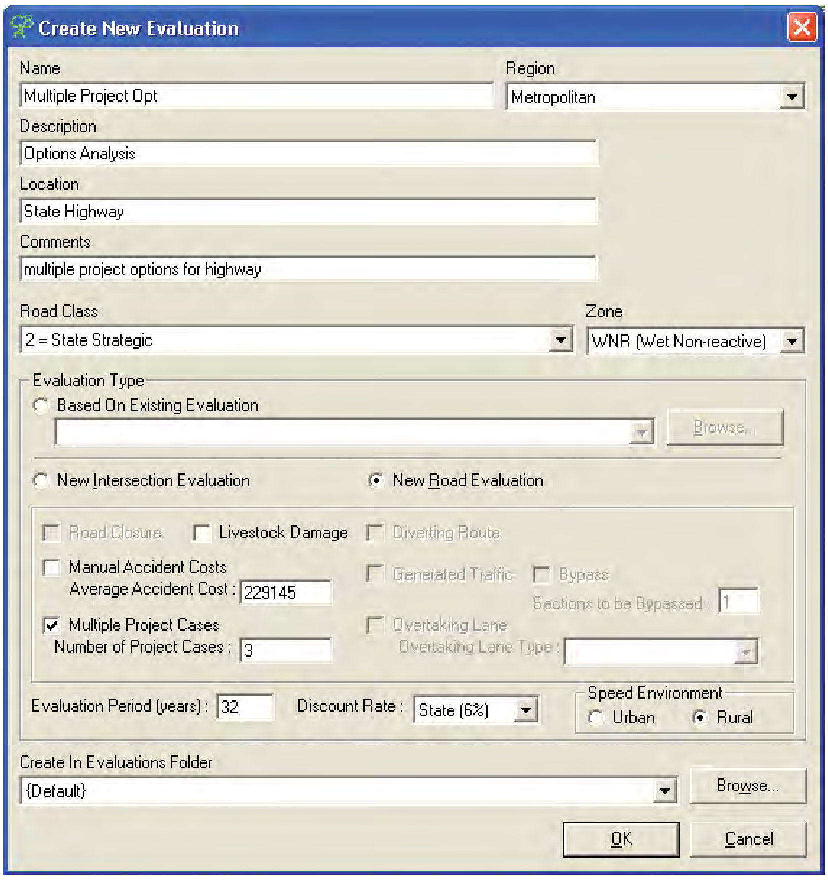
The base case and project options are:

- Base case: a do-minimum strategy has been assumed for the base case. Annual routine maintenance and periodic maintenance in Years 14, 21 and 28 are assumed to occur, while the design of the road will remain constant throughout the evaluation period.
- Option 1: widen the road to 7.6 m over two years. Capital costs at $5 million. Project opening in Year 3 will delay rehabilitation until Year 23. Provide periodic maintenance in Years 9, 16 and 30.
- Option 2: widen the road to 11.6 m over two years. Capital costs at $10 million. Project opening in Year 3 will delay rehabilitation until Year 23. Provide periodic maintenance in Years 9, 16 and 30.
- Option 3: build new four-lane highway (undivided) over two years. Capital costs at $18 million. Project opening in Year 3 will delay rehabilitation until Year 23. Provide periodic maintenance in Years 9, 16 and 30.

5.12.2 Create new evaluation

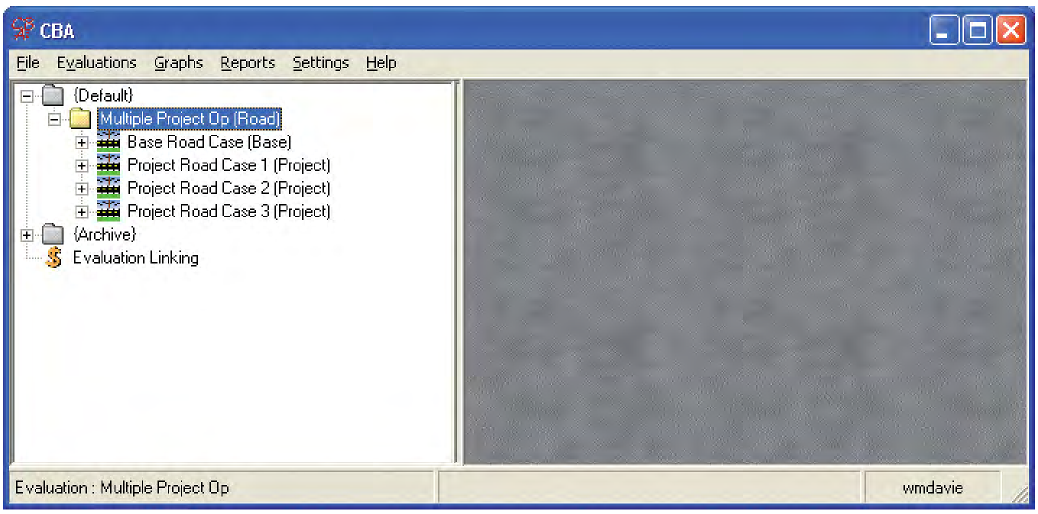
To create an options analysis in CBA6 the ‘multiple project cases’ module must be selected from the ‘create new evaluation’ screen. The system user is required to enter in the number of mutually exclusive project options to be evaluated. In this case study there are three project options, see Figure 182.

Figure 182: Multiple project cases evaluation



The node tree for this case study is shown in Figure 183. There are three project options that will be assessed against the same base case.

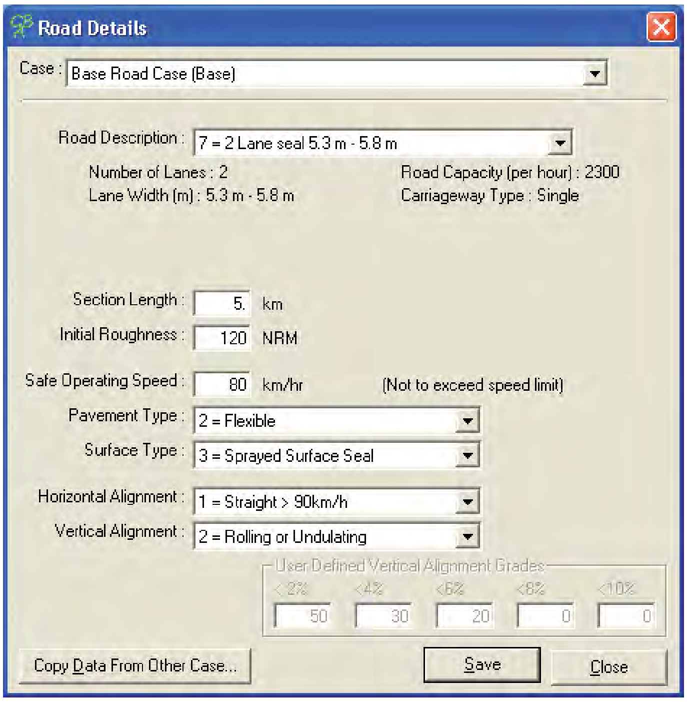
Figure 183: Multiple project workspace



5.12.3 Road details

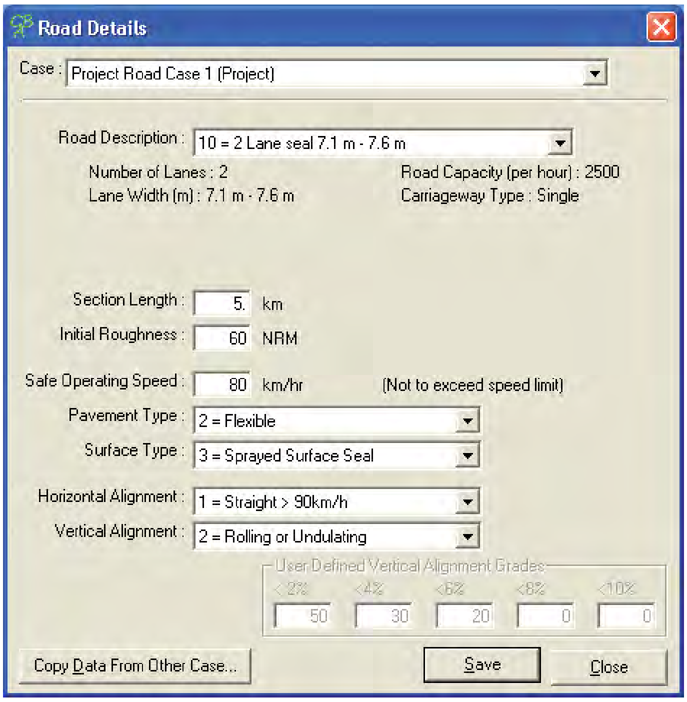
The ‘road details’ screen for the base case is shown in Figure 184. The current road is a narrow two-lane highway.

Figure 184: Base case option



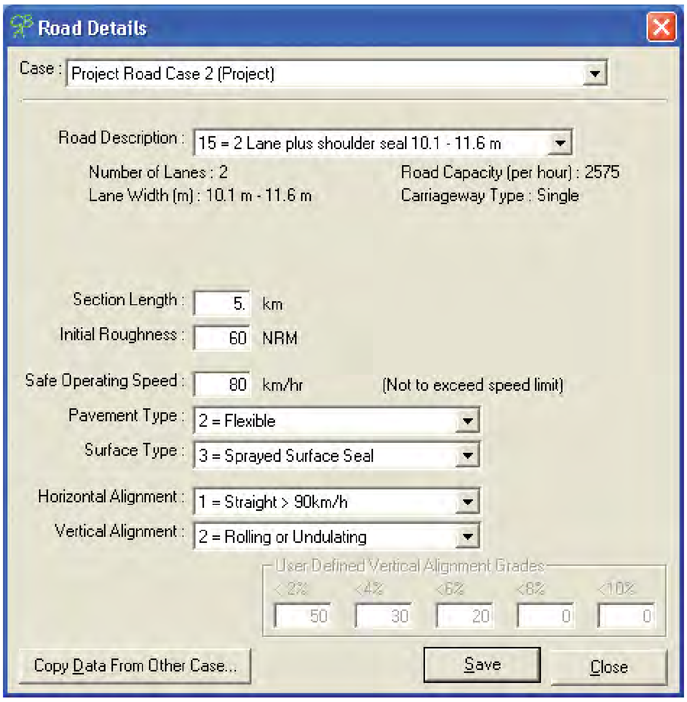
The first project option will widen the road from 5.8 metres to 7.6 metres. The new road will be built to a 60 NRM standard. Road details for option 1 are shown in Figure 185.

Figure 185: Project case option 1



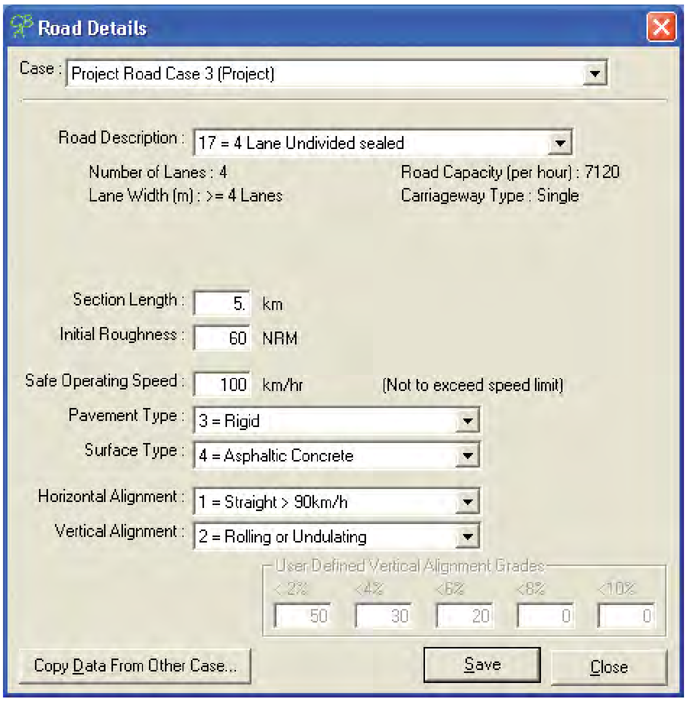
The second proposed upgrade to the road involves a significant widening of the base case. Project option 2 involves widening the base case from 5.8 to 11.6 metres, see Figure 186.

Figure 186: Project case option 2



The final project option involves building a new four-lane highway. Project option 3 also involves increasing the speed limit on the road from 80 km/h to 100 km/h. Details for option 3 are shown in Figure 187.

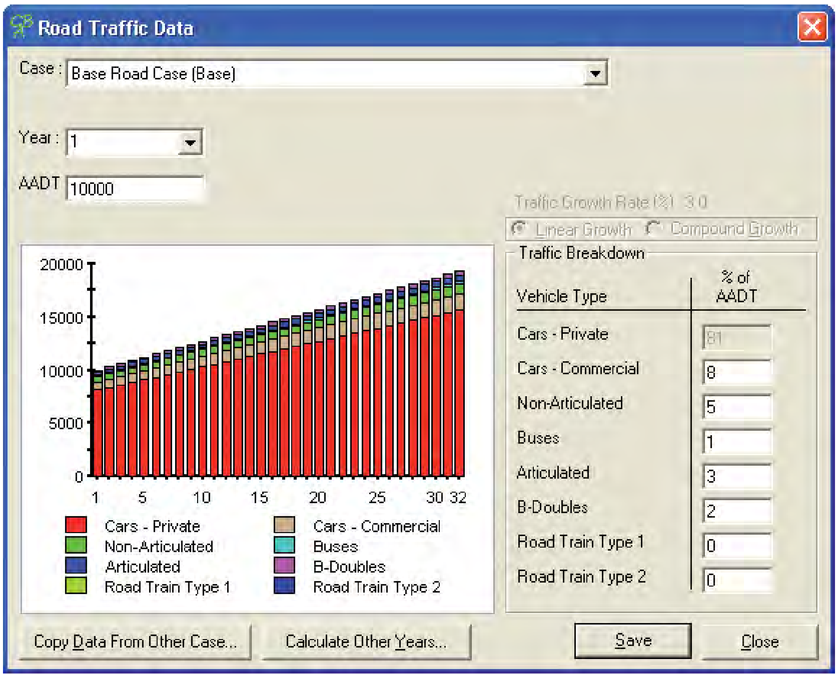
Figure 187: Project case option 3



5.12.4 Road traffic data

Traffic on the current road is 10 000 vehicles per day, with an assumed 3% linear annual growth. Traffic data is shown in Figure 188. The traffic assumptions for the project options will remain the same as the base case.

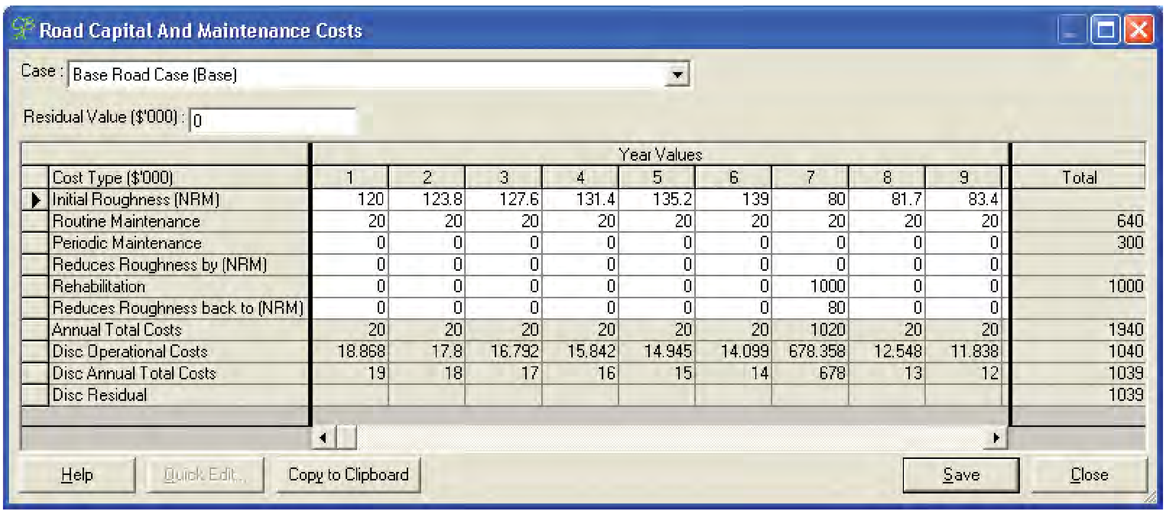
Figure 188: Road traffic data multiple base case



5.12.5 Capital and maintenance

Maintenance costs for the base case are shown in Figure 189. Rehabilitation will take place in Year 7 and will reduce roughness of the road to 80 NRM.

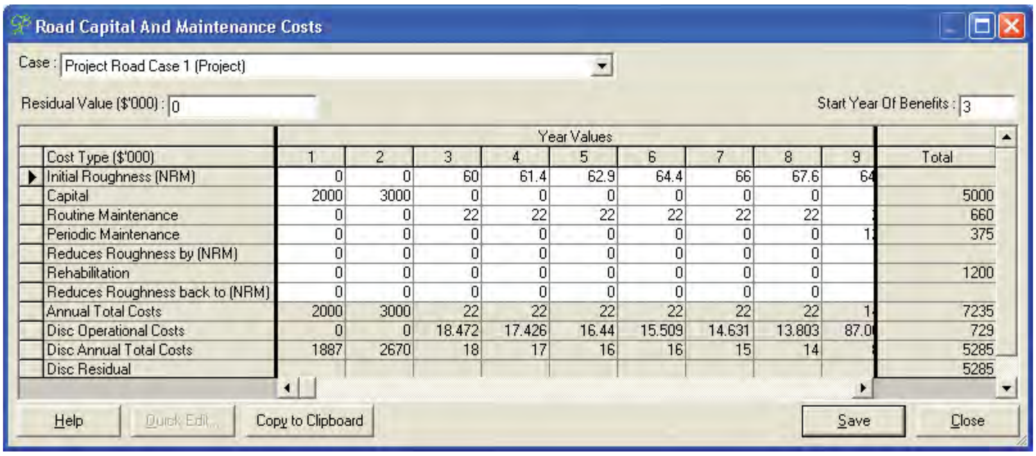
Figure 189: Base case costs



Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	120	123.8	127.6	131.4	135.2	139	80	81.7	83.4	
Routine Maintenance	20	20	20	20	20	20	20	20	20	640
Periodic Maintenance	0	0	0	0	0	0	0	0	0	300
Reduces Roughness by (NRM)	0	0	0	0	0	0	0	0	0	
Rehabilitation	0	0	0	0	0	0	1000	0	0	1000
Reduces Roughness back to (NRM)	0	0	0	0	0	0	80	0	0	
Annual Total Costs	20	20	20	20	20	20	1020	20	20	1940
Disc Operational Costs	18.868	17.8	16.792	15.842	14.945	14.099	678.358	12.548	11.838	1040
Disc Annual Total Costs	19	18	17	16	15	14	678	13	12	1039
Disc Residual										1039

Project option 1 has total capital costs of $5 million. Figure 190 shows the capital and maintenance costs for option 1.

Figure 190: Project option 1 costs



Road Capital And Maintenance Costs

Case : Project Road Case 1 (Project)

Residual Value ($'000) : 0   Start Year Of Benefits : 3

	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	0	60	61.4	62.9	64.4	66	67.6	64	
Capital	2000	3000	0	0	0	0	0	0		5000
Routine Maintenance	0	0	22	22	22	22	22	22		660
Periodic Maintenance	0	0	0	0	0	0	0	0	1	375
Reduces Roughness by (NRM)	0	0	0	0	0	0	0	0		
Rehabilitation	0	0	0	0	0	0	0	0		1200
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	2000	3000	22	22	22	22	22	22	1	7235
Disc Operational Costs	0	0	18.472	17.426	16.44	15.509	14.631	13.803	87.0	729
Disc Annual Total Costs	1887	2670	18	17	16	16	15	14		5285
Disc Residual										5285

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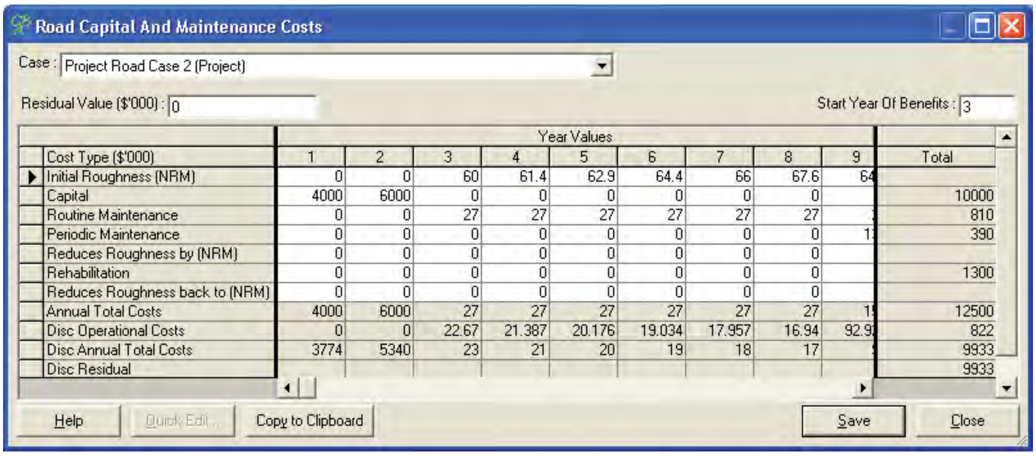
Project option 2 involves widening the current road to 11.6 metres. This is expected to cost $4 million in Year 1 with an additional $6 million in Year 2. These costs are shown in Figure 191.

Figure 191: Project option 2 costs



Road Capital And Maintenance Costs

Case : Project Road Case 2 (Project)

Residual Value ($'000) : 0   Start Year Of Benefits : 3

	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	0	60	61.4	62.9	64.4	66	67.6	64	
Capital	4000	6000	0	0	0	0	0	0		10000
Routine Maintenance	0	0	27	27	27	27	27	27		810
Periodic Maintenance	0	0	0	0	0	0	0	0	1	390
Reduces Roughness by (NRM)	0	0	0	0	0	0	0	0		
Rehabilitation	0	0	0	0	0	0	0	0		1300
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	4000	6000	27	27	27	27	27	27	1	12500
Disc Operational Costs	0	0	22.67	21.387	20.176	19.034	17.957	16.94	92.9	822
Disc Annual Total Costs	3774	5340	23	21	20	19	18	17		9933
Disc Residual										9933

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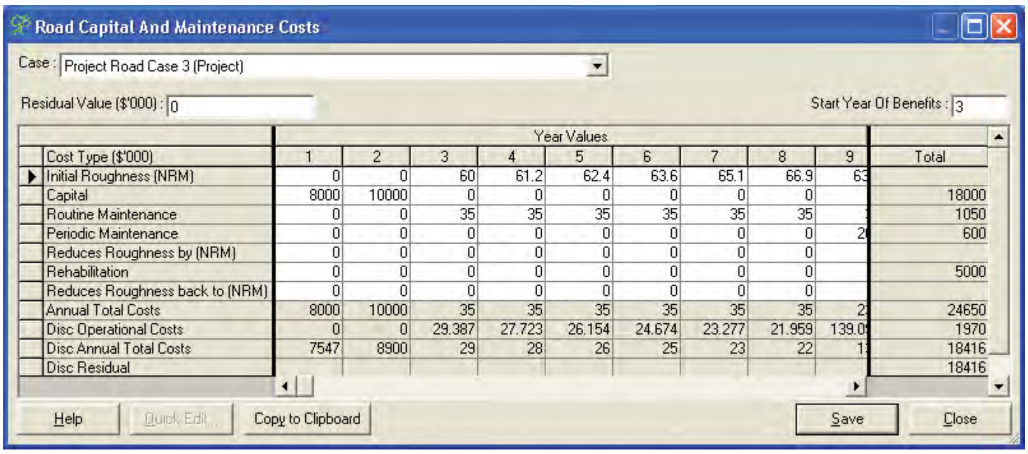
The highest cost project option is the new four-lane highway. This option will cost $18 million and take two years to construct. Figure 192 shows the capital and maintenance costs for option 3.

Figure 192: Project option 3 costs



Road Capital And Maintenance Costs

Case : Project Road Case 3 (Project)

Residual Value ($'000) : 0   Start Year Of Benefits : 3

	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	0	60	61.2	62.4	63.6	65.1	66.9	63	
Capital	8000	10000	0	0	0	0	0	0		18000
Routine Maintenance	0	0	35	35	35	35	35	35		1050
Periodic Maintenance	0	0	0	0	0	0	0	0	2	600
Reduces Roughness by (NRM)	0	0	0	0	0	0	0	0		
Rehabilitation	0	0	0	0	0	0	0	0		5000
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	8000	10000	35	35	35	35	35	35	2	24650
Disc Operational Costs	0	0	29.387	27.723	26.154	24.674	23.277	21.959	139.0	1970
Disc Annual Total Costs	7547	8900	29	28	26	25	23	22	1	18416
Disc Residual										18416

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5.12.6 Accident and other costs

Accident costs are automatically calculated by CBA6. Project options 2 and 3 will provide the highest accident cost savings due to wider seal widths.

5.12.7 Results and decision criteria

The 'results' tab from the node tree provides a breakdown of costs for each option and the results of the incremental analysis, see Figure 193.

The 'incremental analysis' tab shows the final results of the comparison between each project option. The individual results for each project option are shown in project road case 1, project road case 2, and project road case 3 columns respectively. CBA6 automatically arranges project options on a capital costs basis, hence column 1 contains the project option with the lowest capital costs and column 5 contains the project option with the highest capital costs. All results are shown at the discount rate specified in the 'create new evaluation' screen. A discount rate of 6% is used for this example.

In the second column (incremental from project road case 1 to project road case 2), CBA6 calculates the incremental benefit and cost results. This column shows that option 2 costs $4.6 million more than option 1. On the other hand option 2 has an additional $12.9m in benefits. The IBCR for option 1 to option 2 is 2.78, therefore option 2 is preferred over option 1.

In the fourth column (incremental from project road case 2 to project road case 3), CBA6 calculates the incremental benefit and cost for option 2 and option 3. This result shows that option 3 costs $8.4 million more than option 2 but only provides $3.15 million more benefits. The IBCR is 0.37, therefore option 2 is preferred over option 3. In cases where the IBCR does not suitably identify a preferred option, the NPV can be used to select the preferred option.

The results of this incremental analysis show option 2 to be the preferred choice to upgrade the current highway.

Figure 193: Multiple project case results

Results - Incremental Analysis

Case Name	Project Road Case 1	Increment from Project Road Case 1 -> Project Road Case 2	Project Road Case 2	Increment from Project Road Case 2 -> Project Road Case 3	Project Road Case 3
Discounted Costs	4,245,463	4,650,013	8,895,476	8,481,402	17,376,878
Discounted Capital Costs	4,556,782	4,556,782	9,113,564	7,333,571	16,447,134
Discounted Other Costs	-311,319	93,231	-218,087	1,147,831	929,743
Discounted Benefits	29,232,431	12,923,520	42,155,951	3,148,314	45,304,265
Private TTC Savings	2,062,192	594,565	2,656,757	12,852,146	15,508,903
Commercial TTC Savings	1,548,276	206,501	1,754,777	3,321,217	5,075,994
Private VOC Savings	1,629,284	35,079	1,664,363	-2,008,067	-343,703
Commercial VOC Savings	1,112,566	28,938	1,141,504	732,264	1,873,768
Discounted Accident Savings	22,880,112	12,058,438	34,938,550	-11,749,247	23,189,303
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Livestock Damage	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Net Present Value (NPV)	24,986,968	8,273,507	33,260,475	-5,333,087	27,927,388
Net Present Value per dollar	5.48	1.82	3.65	-0.73	1.70
Benefit Cost Ratio Excl. Private Time	6.40	2.65	4.44	-1.14	1.71
Benefit Cost Ratio	6.89	2.78	4.74	0.37	2.61

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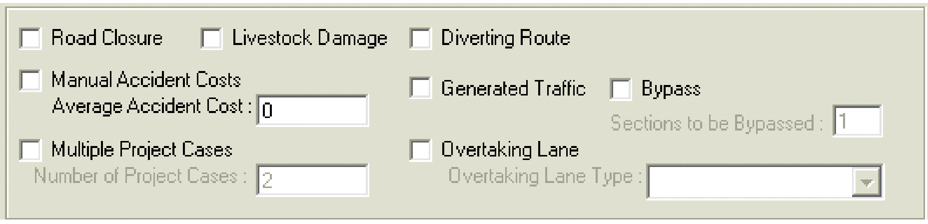
Note: Section 9.5 of the *Technical Guide* provides background information on calculation of the IBCR.

5.13 Incremental analysis

The 'evaluation linking' incremental analysis function in CBA6 is usually engaged to evaluate and compare project options which require the use of the advanced module in CBA6. This function is only available for system users who are evaluating options comprising one of the six project types listed in Figure 194. For example, a comparison between different types of overtaking lanes (e.g. head-to-head in comparison to side-by-side) cannot be evaluated using the 'multiple project case' option.

Figure 194: CBA6 advanced modules



This case study will use the bypass project presented in Section 5.7. This case study involves a proposal to build a new two-lane highway to bypass a local town. As an alternative, it is proposed that a four-lane undivided highway be constructed to allow for additional capacity.

5.13.1 Incremental case study

A new evaluation will be created in CBA6 and then compared with the original bypass case study (original proposal) in Section 5.7. A four-lane undivided highway (alternative option) has also been proposed as a comparison. This alternative option allows for an increased road capacity but has higher capital costs than the original proposal.

Note: The new base case to be created in CBA6 must remain consistent with the original proposal. The only changes will be the project case MRS, pavement type, surface type and capital cost. The changes need to be entered into CBA6 through the 'road details' and the 'capital and maintenance costs' functions. The alternative option can be created in CBA6 using the original proposal as a basis, see Section 3.1.8.1.

5.13.2 Create new evaluation

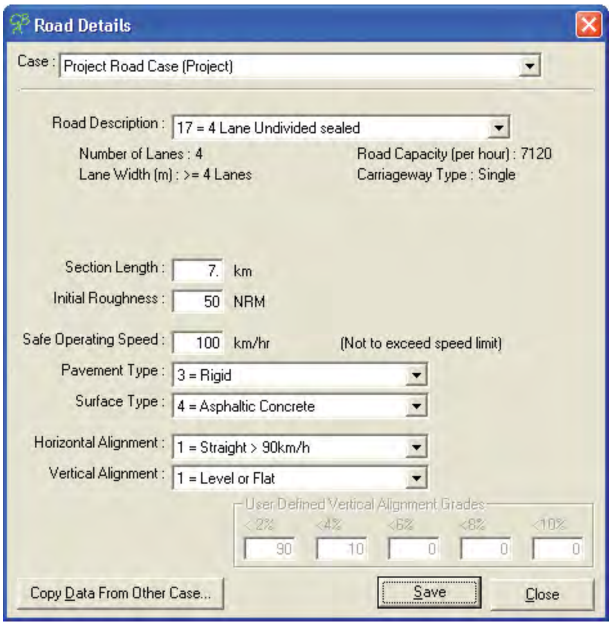
The alternative option is based on the original proposal in Section 5.7, therefore the system user should select the ‘based on existing evaluation’ option, see Figure 195.

Figure 195: Town bypass option 2

5.13.3 Road details

The alternative option will have an MRS of 17. The pavement type and surface type are changed to rigid and asphaltic concrete respectively. Figure 196 shows the road details for all options.

Figure 196: Undivided bypass option



5.13.4 Capital and maintenance costs

The only other change needed within CBA6 relates to the capital costs. The capital costs for the alternative proposal are $80 million, see Figure 197.

Figure 197: Undivided bypass option costs

Road Capital And Maintenance Costs

Case : Project Road Case (Project)

Residual Value ($'000) : 0

Start Year Of Benefits : 3

	Year Values									
Cost Type ($'000)	1	2	3	4	5	6	7	8	9	Total
Initial Roughness (NRM)	0	0	50	51.3	52.6	53.9	55.2	51.5	52	
Capital	10000	70000	0	0	0	0	0	0		80000
Routine Maintenance	0	0	20	20	20	20	20	20		600
Periodic Maintenance	0	0	0	0	0	0	0	1000		3000
Reduces Roughness by (NRM)	0	0	0	0	0	0	0	5		
Rehabilitation	0	0	0	0	0	0	0	0		3000
Reduces Roughness back to (NRM)	0	0	0	0	0	0	0	0		
Annual Total Costs	10000	70000	20	20	20	20	20	1020		86600
Disc Operational Costs	0	0	16.792	15.842	14.945	14.099	13.301	639.961	11.8	2307
Disc Annual Total Costs	9434	62300	17	16	15	14	13	640		74040
Disc Residual										74040

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Note: When the costs of both options are compared, all maintenance costs have remained the same.

5.13.5 Results and decision criteria

The results of the alternative option are shown in Figure 198. At the 6% discount rate, the project BCR is 1.06 and the NPV is $4.13 million. These results indicate the alternative option is economically justified. To determine which of the project options is preferred, the system user should compare the evaluation results.

Figure 198: Undivided bypass option results

Results - Decision Criteria Recalc No 2

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	76,632,863	73,336,273	71,833,106	70,408,921	67,759,124
Discounted Capital Costs	74,334,320	71,733,713	70,486,505	69,272,977	66,942,149
Discounted Other Costs	2,298,544	1,602,560	1,346,600	1,135,944	816,975
Discounted Benefits	104,305,331	77,470,986	67,540,379	59,306,875	46,648,605
Private TTC Savings	43,772,571	32,623,493	28,487,975	25,054,042	19,763,163
Commercial TTC Savings	31,174,794	23,234,873	20,289,720	17,844,201	14,076,206
Private VOC Savings	12,245,777	8,954,878	7,748,958	6,755,568	5,242,713
Commercial VOC Savings	10,391,512	7,648,854	6,639,789	5,806,359	4,532,161
Discounted Accident Savings	6,720,677	5,008,889	4,373,937	3,846,704	3,034,362
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	27,672,468	4,134,713	-4,292,726	-11,102,046	-21,110,519
Net Present Value per dollar Investment	0.37	0.06	-0.06	-0.16	-0.32
Benefit Cost Ratio Excl. Private Time	0.79	0.61	0.54	0.49	0.40
Benefit Cost Ratio	1.36	1.06	0.94	0.84	0.69
First Year Rate of Return	5.67%	5.55%	5.49%	5.43%	5.32%

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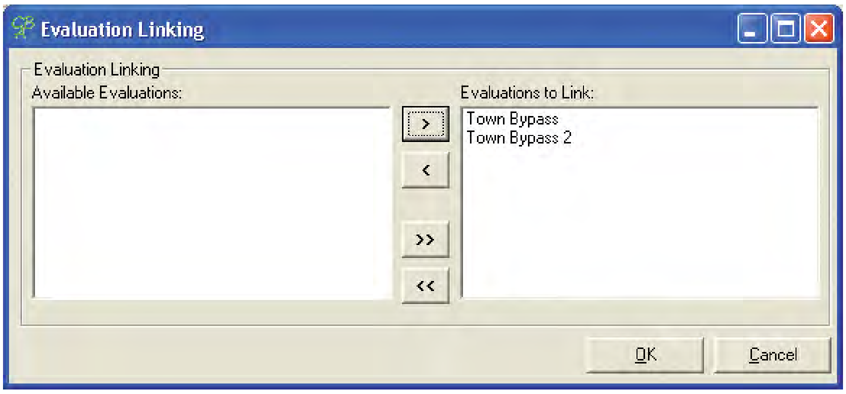
5.13.6 Linking

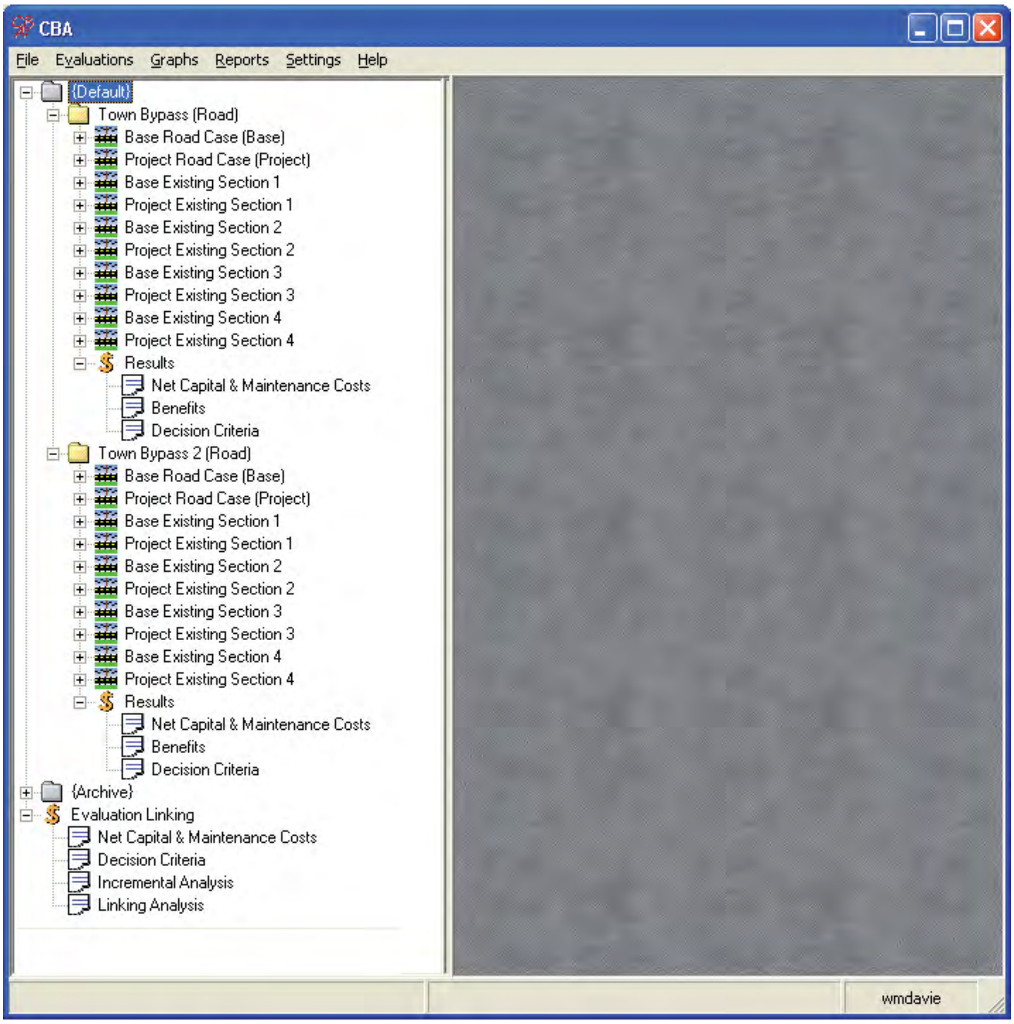
The original proposal and the alternative option are compared using the 'evaluation linking' option, see Figure 199.

Figure 199: Evaluation linking



The 'incremental analysis' tab presents the comparison of the evaluation results for both project options, see Figure 200.

Figure 200: Incremental analysis



The results of the incremental analysis are presented in Figure 201. The second column (incremental from town bypass to town bypass 2) presents the incremental analysis of the original proposal and the alternative option.

The results suggest that the alternative option will cost an additional $17.8 million more than the original proposal. The original proposal has an estimated $2.76 million more benefits than the alternative option. The IBCR of -0.16 suggests that the lower cost original proposal is the preferred option.

Figure 201: Incremental analysis results for town bypass options

Results - Incremental Analysis

Evaluation Name	Town Bypass	Increment from Town Bypass -> Town Bypass 2	Town Bypass 2
Discounted Costs	55,536,345	17,799,929	73,336,273
Discounted Capital Costs	53,933,784	17,799,929	71,733,713
Discounted Other Costs	1,602,560	0	1,602,560
Discounted Benefits	80,232,409	-2,761,423	77,470,986
Private TTC Savings	32,623,493	0	32,623,493
Commercial TTC Savings	22,957,177	277,696	23,234,873
Private VOC Savings	8,649,728	305,149	8,954,878
Commercial VOC Savings	7,703,333	-54,479	7,648,854
Discounted Accident Savings	8,298,679	-3,289,789	5,008,889
Discounted Emission Savings	0	0	0
Discounted Environment Savings	0	0	0
Discounted Secondary Savings	0	0	0
Discounted Other Savings	0	0	0
Discounted Livestock Damage	0	0	0
Discounted Road Closure Savings	0	0	0
Net Present Value (NPV)	24,696,064	-20,561,352	4,134,713
Net Present Value per dollar	0.46	-1.16	0.06
Benefit Cost Ratio Excl. Private Time	0.86	-0.16	0.61
Benefit Cost Ratio	1.44	-0.16	1.06

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5.14 Linking projects

The 'linking projects' function in CBA6 is used to combine the results of mutually dependent projects. For example, two single projects may not achieve sufficient benefits as standalone projects to warrant construction. However, sufficient benefits may be obtained when the results of these projects are combined. A practical example could include combining a bridge upgrade with an approach, combining an intersection with a road upgrade, or combining a sequence of programmed works.

5.14.1 Linking projects case study

This case study will describe the process of using CBA6 to combine the results of an intersection project and an arterial road upgrade.

There are two proposed upgrades:

- Intersection upgrade – from case study in Section 5.5, a stop sign intersection is upgraded to signalised operations.
- Upgrade the approaches to the intersection – the main arterial road will be upgraded to coincide with the upgrade to the intersection.

The approach to this intersection is quite narrow and could become congested with the onset of additional traffic, as the intersection acts as a direct feeder of traffic onto the road. Upgrading the intersection as a standalone project may result in severe congestion issues for motorists using the arterial road. These design features suggest that these two projects have a high degree of mutual dependency and overall transport objectives may only be met if both projects are initiated.

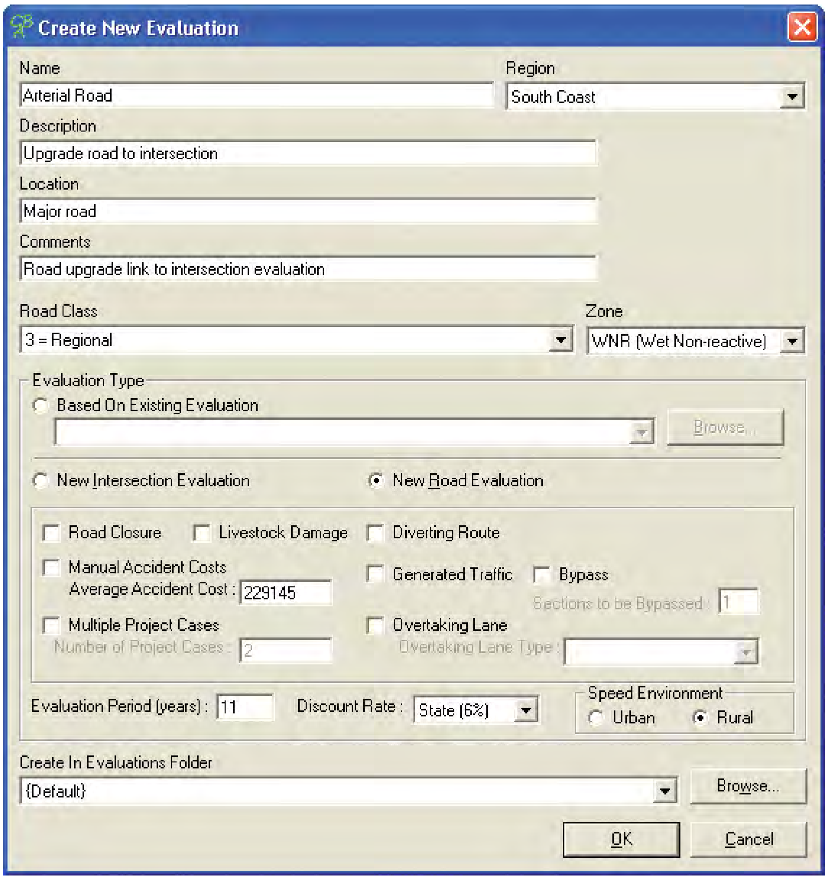
This case study will work through and describe the steps required to link the results of both projects. As the intersection project has already been completed in CBA6, the only new evaluation that needs to be created is the arterial road upgrade.

5.14.2 Create new evaluation

The 'create new evaluation' screen for the arterial road upgrade is shown in Figure 202. System users should ensure that the results of all linked projects are evaluated and discounted using the same discount rate. The arterial road upgrade uses an evaluation period of 11 years which is the evaluation period used for the intersection upgrade. The evaluation period for road projects is usually set at around 30 years. A residual value will be calculated for the road upgrade in this case study.

The details for the arterial road upgrade are entered into CBA6 as per the previous case studies and via the instruction shown in Section 3. All project input data is shown in Appendix A .

Figure 202: Arterial road evaluation



5.14.3 Results and decision criteria

After the input data has been entered and saved, the evaluation results can be calculated for the arterial road upgrade. As shown in Figure 203, the BCR for the arterial road upgrade is 0.66. As a standalone evaluation, it is doubtful that this project is economically viable.

To investigate the viability of combining the evaluation results of the two projects, it is necessary to link the results of both the arterial road upgrade and intersection upgrade.

Figure 203: Arterial road results

Results - Decision Criteria Recalc No 3

Discount Rate	4%	6%	7%	8%	10%
Discounted Costs	1,418,277	1,556,809	1,612,225	1,659,863	1,735,380
Discounted Capital Costs	2,403,846	2,358,491	2,336,449	2,314,815	2,272,727
Discounted Other Costs	-985,569	-801,682	-724,224	-654,952	-537,347
Discounted Benefits	1,149,332	1,025,064	969,878	918,766	827,347
Private TTC Savings	0	0	0	0	0
Commercial TTC Savings	0	0	0	0	0
Private VOC Savings	197,913	180,865	173,128	165,861	152,597
Commercial VOC Savings	22,052	20,109	19,230	18,405	16,903
Discounted Accident Savings	929,367	824,090	777,520	734,500	657,847
Discounted Emission Savings	0	0	0	0	0
Discounted Environment Savings	0	0	0	0	0
Discounted Secondary Savings	0	0	0	0	0
Discounted Other Savings	0	0	0	0	0
Discounted Road Closure Savings	0	0	0	0	0
Discounted Livestock Damage Benefits	0	0	0	0	0
Discounted Generated Traffic Benefits	0	0	0	0	0
Net Present Value (NPV)	-268,945	-531,745	-642,347	-741,096	-908,033
Net Present Value per dollar Investment	-0.11	-0.23	-0.27	-0.32	-0.40
Benefit Cost Ratio Excl. Private Time	0.81	0.66	0.60	0.55	0.48
Benefit Cost Ratio	0.81	0.66	0.60	0.55	0.48
First Year Rate of Return	4.85%	4.76%	4.72%	4.67%	4.59%

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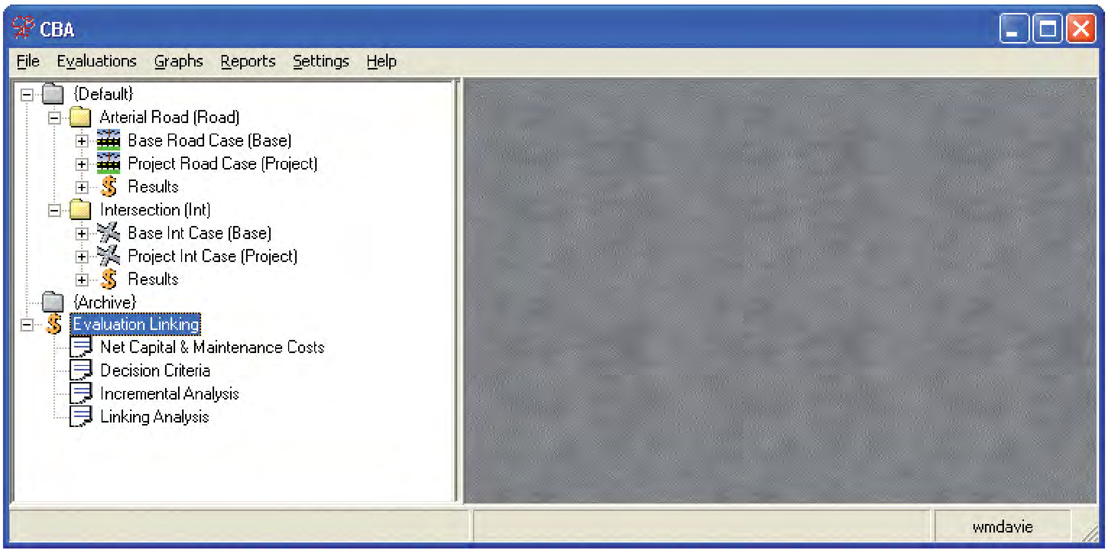
5.14.4 Linking analysis

When the evaluation results of both projects have been completed and saved, the results are linked using the 'evaluations' menu. After the evaluation files have been successfully linked, a new node tree appears under the 'evaluation linking' tab. To run the combined analysis of the arterial road and intersection upgrades, the system user selects the 'linking analysis' tab, see Figure 204.

Figure 204: Linking analysis

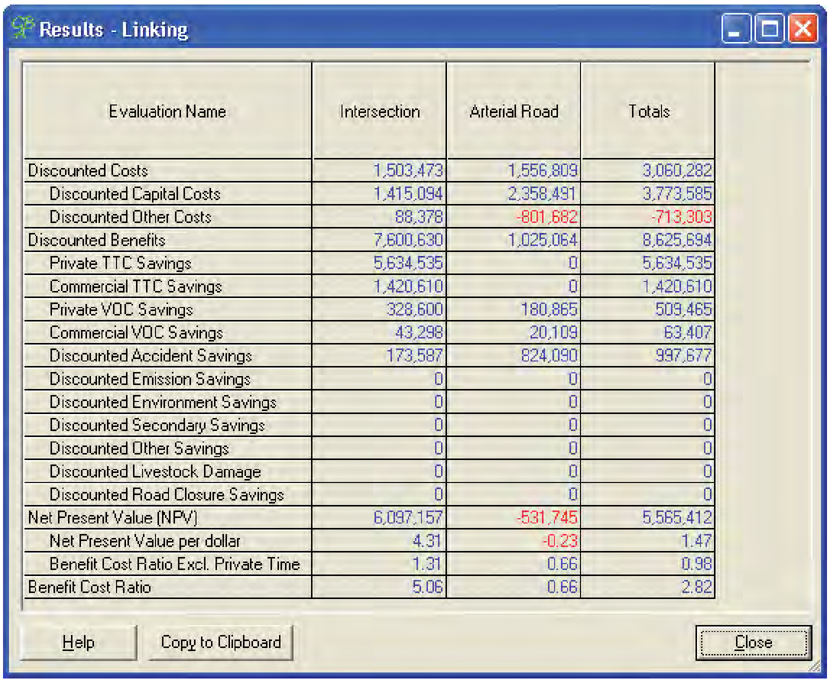


From the 'linking analysis' tab, CBA6 combines the results of both the intersection and arterial road evaluation files, see Figure 205.

The combined BCR for both projects is 2.82 with an NPV of $5.56 million, using the 6% discount rate. This suggests that upgrading the arterial road and the intersection as a joint initiative will significantly lower TTC and VOC, and reduce accidents.

This demonstration highlights that although the intersection project is viable as a standalone project (BCR = 5.06), the construction of the arterial road upgrade is not (BCR = 0.66). If the evaluation results of these projects are assessed individually, the intersection upgrade would be economically viable, but the proposal to upgrade the arterial road upgrade would fail. CBA6 can be used to link the evaluation results of two mutually dependent projects. The arterial road project may not be viable unless the evaluation results of both projects are assessed as a joint initiative.

Figure 205: Linking results – arterial road and intersection


Results - Linking

Evaluation Name	Intersection	Arterial Road	Totals
Discounted Costs	1,503,473	1,556,809	3,060,282
Discounted Capital Costs	1,415,094	2,358,491	3,773,585
Discounted Other Costs	88,378	-801,682	-713,303
Discounted Benefits	7,600,630	1,025,064	8,625,694
Private TTC Savings	5,634,535	0	5,634,535
Commercial TTC Savings	1,420,610	0	1,420,610
Private VOC Savings	328,600	180,865	509,465
Commercial VOC Savings	43,298	20,109	63,407
Discounted Accident Savings	173,587	824,090	997,677
Discounted Emission Savings	0	0	0
Discounted Environment Savings	0	0	0
Discounted Secondary Savings	0	0	0
Discounted Other Savings	0	0	0
Discounted Livestock Damage	0	0	0
Discounted Road Closure Savings	0	0	0
Net Present Value (NPV)	6,097,157	-531,745	5,565,412
Net Present Value per dollar	4.31	-0.23	1.47
Benefit Cost Ratio Excl. Private Time	1.31	0.66	0.98
Benefit Cost Ratio	5.06	0.66	2.82

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