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Ex-post economic evaluation of National Highway projects Case study 2: Northam Bypass

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Ex-post economic evaluation of National Highway projects

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Foreword

BTRE's ex-post road investments evaluation project involves systematically reviewing after the fact the projected costs and benefits of major investments. The project complements the recent implementation by jurisdictions of the ATC-endorsed National Guidelines for Transport System Management in Australia. In particular, the project is intended to benefit both future project appraisal and future ex-post evaluation under AusLink and more generally.

This analysis was one of the case studies undertaken for the BTRE ex-post road investments evaluation project. The case study provided an example of how to undertake an evaluation of a bypass project involving an improved treatment of delay effects at intersections using the Main Roads Western Australia's WARES evaluation software.

The BTRE wishes to thank Main Roads Western Australia (MRWA) for their support to this project. In particular, thanks go to Neil Trethowen who assisted in collecting information/data and implementing the BCA calculation for this ex-post evaluation, and commented on the draft of this report.

Dr William Lu was the principal researcher for this case study. Dr Mark Harvey and Quentin Reynolds (BTRE) provided advice and comments at the various stages of the project.

Phil Potterton
Executive Director
Bureau of Transport and Regional Economics
May 2007

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Executive summary

This case study provides a review of the ex-ante benefit-cost analysis (BCA) undertaken by MRWA (1999) for the Northam Bypass project and carries out an ex-post economic evaluation. Adjustments made in the ex-post analysis include:

E1 improving the treatment of intersection effects;

E2 removing the $8m savings to the freight industry that have not been realised;

E3 changing the construction costs and project timing;

E4 changing the traffic levels and growth;

E5 changing the average crash costs; and

E6 changing the discount rate.

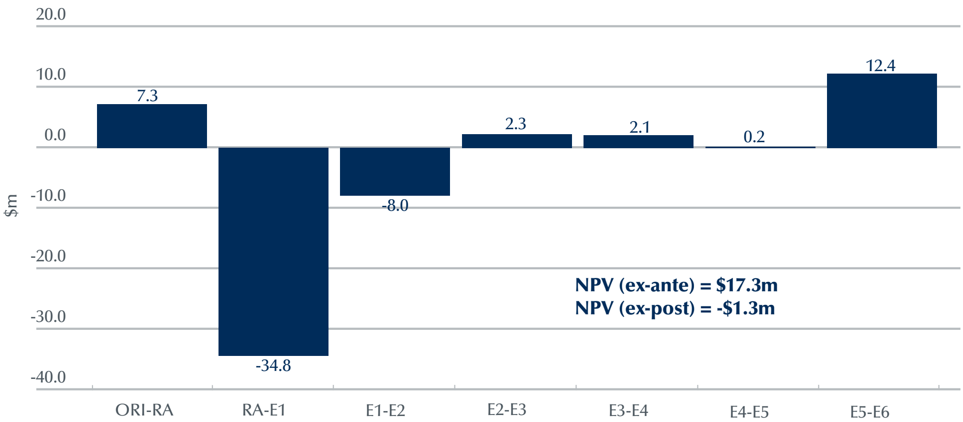
The number of adjustments introduced in this ex-post evaluation was fewer than for the other case studies in this series. The freight time benefits recommended by Austroads were not estimated due to the limitations of the RURAL3 modelling software. Because of the complex nature of the Northam road network and the amount of information required, changes in vehicle composition and crash rates were not updated for the ex-post evaluation in this case study.

The net present value (NPV) was used as an indicator to show the contribution of each variation to the total difference between the ex-ante and ex-post evaluation results. The components of the total variation in NPV are illustrated in Figure 1. The ex-post NPV was -$1.3m, which was $18.6m lower than the ex-ante estimate. The change in the methodology of treating the delay effects caused by intersections (RA-E1) contributed -$34.8m (or 187.1 per cent) to the total $18.6m difference in NPV. The variation in the freight-related benefits (E1-E2) contributed -$8m (or 43.0 per cent).

Of the adjustments that led to an increase in the NPV, lowering the discount rate from 7 per cent to 3 per cent (E5-E6) was the most significant ($12.4m). Changing construction costs and project timing (E2-E3) increased the NPV by $2.3m. Improved traffic data and modelling (E3-E4) lifted the NPV by $2.1m.

The results of the ex-post evaluation reported above should not be viewed as fully definitive because there were a number of factors not updated or calculated—for example, changes in the actual traffic composition and crash rates, incorporation of the impact of intersections on Vehicle Operating Cost (VOC) savings, inclusion of the Austroads-recommended freight benefits and the improvement in local amenity.

Figure 1 Sources of variation in NPV



Note: ORI=original analysis. RA=reconstructed analysis.

A major lesson drawn from this case study is about how intersections should be treated in the economic evaluation of a bypass project. In the ex-ante analysis, extra lengths were added to various links to take into account delay effects caused by intersections in the base case. This approach caused an underestimation of travel speeds for the base case and hence an overestimation of travel time savings. It also led to a large overestimation of savings in VOCs and crash costs.

A number of alternative approaches could be used to handle the effects of intersection delays. For the ex-post evaluation undertaken in this case study, reducing the maximum speeds through a change in the speed limits along the townsite route was used as a proxy for the impedance of intersections. This approach had two advantages compared with the approach used in the original analysis. First, working on speeds was a more direct approach, which could allow assumptions about speeds to be checked against the real world data. Second, it avoided major distortions in the calculated savings in VOCs and crash costs, although the effect on VOC savings of the stop-start nature of intersections could not be captured.

In future town bypass evaluations, extreme care should be taken in selecting a methodology for modelling intersection delays for the base case. The adequacy of the assumptions made about travel speeds should be cross-checked against real-world observations, if possible.

Another lesson relates to the inclusion of non-standard road user benefits. The ex-ante analysis included an $8m benefit to the freight industry as measured in savings in travel time costs and VOCs due to the reduced distance travelled by shuttle vehicles between Perth and the road train assembly area.

The construction of Northam Bypass was a necessary but not a sufficient condition to enable road trains to travel closer to Perth. Other complementary works, including the relocation of the road train assembly area, were required. The costs of these complementary works should be included as part of the total project costs before any additional benefits can be claimed.

Other important lessons learned from the project point to the need for accurate reporting and better documentation of BCA inputs and improved traffic analysis.

Chapter 1 Introduction

This case study forms part of a larger ex-post evaluation project undertaken by the BTRE. The objectives of the case study are to:

- check the accuracy of the ex-ante benefit-cost analysis (BCA) for the Northam Bypass project through an ex-post BCA evaluation;
- reveal sources of differences (if any) in results between the ex-ante and ex-post BCAs; and
- draw lessons from the case study in order to improve BCAs (both ex-ante and ex-post) for future projects.

A unique feature of this case study is that it provides an example of how to undertake an evaluation of a bypass project involving an improved treatment of delay effects caused by intersections for the base case routes.

Two qualifications are required in relation to the ex-post evaluation results of this case study. First, the original economic evaluation undertaken for this project was not necessarily representative of BCA practices in Western Australia (WA). Second, the ex-ante BCA was undertaken about 7 years ago, so it should not be interpreted as representing appraisal practices prevailing in WA today.

The next section provides a brief description of the Northam Bypass project. Section 3 reviews the ex-ante BCA analyses undertaken for the project. Methodological issues for the ex-post evaluation are discussed in Section 4. Section 5 reconstructs the ex-ante analysis using the original version of WARES[1]. Section 6 presents the ex-post evaluation results. Lessons learned are discussed in the final section.

1 Western Australian Road Evaluation System.

Chapter 2 Description of the Northam Bypass project

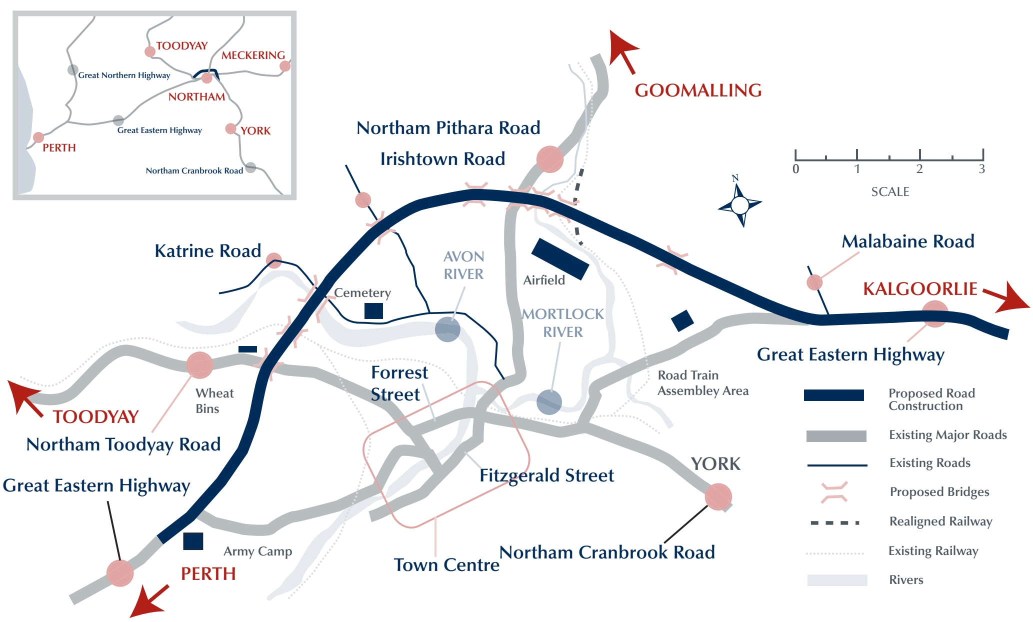
Northam is a town on the Great Eastern Highway (GEH), approximately 97 km east of Perth. Northam has a population of around 7000 and is a major service and administration centre for the WA Central Wheat Belt Region.

Prior to the Northam Bypass being built, the GEH passed through the centre of the town with heavy vehicles having to negotiate the main shopping area, including two railway crossings, four right angle turns and many busy intersections. These vehicles included B-Doubles and truck/trailer combinations up to 67.5 tonnes.

The primary aim of the bypass was to divert through-traffic away from the townsite, thus overcoming the difficulties and dangers of heavy vehicles using the pre-existing route through built-up areas as well as improving the safety and amenity of major streets of Northam.

The Northam Bypass involved construction of a new road approximately 14.9 km long including eight bridges—2 over rivers, 2 over railways and 4 over existing roads (Figure 2). The bypass starts from the old GEH to the west of Northam near the entrance to the Army camp. Passing north-east, it crosses the Northam-Toodyay Road via an overpass north-west of the Colebatch Road intersection and follows an alignment between the town wastewater treatment ponds and the cemetery. It is then carried on a 230-metre bridge over the standard gauge railway line, Avon River and Katrine

Figure 2 Northam Bypass



Road. From Katrine Road, the bypass continues in a north-easterly direction, passing over the Irishtown Road before heading east to cross over the Northam-Pithara Road to the north of the airstrip. From the Northam-Pithara Road back to the existing GEH, the bypass follows a south-easterly alignment, passing north of the racecourse and a road train assembly area. The bypass route connects with the pre-existing highway east of the Katrine Highway.

The total budgeted cost for the project was estimated to be $47m (in 1998 prices) in the Stage 3 Project Proposal Report (PPR). Federal Government funding was capped at $40m. The State Government was committed to bear any additional cost in excess of $40m. The actual project cost was $49.4m (nominal).

The project commenced in January 2001 and was completed in May 2002.

For a more detailed account of the history of the project, refer to appendix A.

Chapter 3 Review of ex-ante BCA analyses

This section provides a brief history of economic evaluations undertaken for the Northam Bypass and reviews in some detail the MRWA (1999) ex-ante BCA analysis, which was the basis for the decision to proceed with the project.

Ex-ante BCA analyses

Prior to the Federal Government's decision to fund the Northam Bypass, there had been several studies looking into the economic viability of the Northam Bypass project (Table 1).

The Stage 2 Project Proposal Reports (MRWA 1992 and 1994) provided cost estimates of the proposed bypass project. However, these reports lacked any economic analysis of road user benefits. As a result, no benefit-cost ratios (BCRs) were available for the project from the Stage 2 PPRs.

Table 1 Ex-ante BCAs for the Northam Bypass project

MM/YY	*Cost Estimate*	*BCR*[a]	*Source*	*Comments*
08/92	$36.1m (1991 prices)	N/A	GEH – H5: *Northam Bypass*, PPR S2 v1, MRWA.	– Economic benefits not quantified. – Base case route: 13.1 km. – Project case route: 13.4 km (Route 6).
08/94	$36.6m (1993 prices)	N/A	GEH – H5: *Northam Bypass*, PPR S2 v2, MRWA.	– Economic benefits not quantified. – Base case route: 13.1 km. – Project case route: 15.7 km (Route 9).
03/95	N/A	0.2	DoTARS File: L95/831, pp. 77 & 148.	No information available on the detail of BCR calculation.
10/95	$40.7m (in 1991 prices)	1.36	*Northam Bypass Proposal*, prepared by BSD Consultants Pty Ltd for MRWA.	– Economic evaluation undertaken by MRWA using WARES. – No detailed documentation available. – Base case route = 13.1 km. – Project case route = 15.7 km (Route 9).
03/99	$47.0m (actual project case route, in 1998 prices)	1.4	GEH – H5: *Northam Bypass*, PPR S3, MRWA.	– Economic evaluation undertaken by MRWA using WARES. – No detailed documentation available. – Base case route = 13.6 km. – Project case route = 14.9 km (Route 9).

a Discounted at 7 per cent per annum.

In March 1995, MRWA undertook an initial estimation of the BCR for the project, which was found to be 0.2. No information was available on the detail of MRWA's BCR calculation.

In October 1995, BSD Consultants Pty Ltd prepared an updated Northam Bypass project proposal report for MRWA. The economic evaluation was undertaken by MRWA using the computer program RURAL—a principal component of WARES. Table 2 provides a summary of MRWA's evaluation results. The BCR was re-assessed to be 1.36.

Table 2 Benefits and costs for the Northam Bypass project ($m, in 1991 prices)

Benefit/Cost Category	*Present values*	*Percentage (%)*
Total Discounted Benefits	**51.9**	**100.0**
Travel time savings	29.8	57.3
VOC savings	18.4	35.6
Accident reduction benefits	3.6	6.9
Savings in road maintenance costs	0.2	0.3
Total Discounted Costs	**38.1**	
Project costs	38.1[a]	
Net Benefits	**13.7**	
BCR	**1.36**	

a Derived by BTRE using information given in BSD (1995), p.15.
Source: BSD (1995), p.15.

In March 1999, MRWA further updated, in its Stage 3 PPR, the economic evaluation of the Northam Bypass project. The study increased the base case road length from 13.1 km to 13.6 km and decreased the length of the bypass road from 15.7 km to 14.9 km. The reasons for these changes were not given. An extra $8m was included as additional savings in time and operating costs to the freight industry from the reduced distance travelled by shuttle vehicles between Perth and the road train assembly area. The estimated project costs increased to $47m. The updated BCR, which is presented in Table 3, was similar to that reported in BSD (1995).

Table 3 Benefits and costs for the Northam Bypass project ($m, In 1998 Prices)

Benefit/Cost Category	*Present values*	*Percentage (%)*
Total Discounted Benefits	**64.3**	**100.0**
Travel time savings	31.7	49.2
VOC savings	19.6	30.5
Accident reduction benefits	4.9	7.6
Savings in road maintenance costs	0.1	0.2
Other benefits (freight related)	8.0	12.4
Total Discounted Costs	**47.0**	
Project costs	47.0	
Net Benefits	**17.3**	
BCR	**1.4**	

Source: MRWA (1999), p.18.

Since the MRWA (1999) evaluation was the basis on which the final decision was made to proceed with the project, it was the focus in our ex-post evaluation.

Review of MRWA (1999) analysis

Review of the MRWA's ex-ante BCA analysis presented below focuses on traffic demand analysis and road and non-road user benefit estimation.

Traffic demand analysis and forecast

The economic evaluation undertaken by MRWA (1999) relied on a "cordon number plate traffic survey" of the Northam townsite undertaken by Uloth and Associates Pty Ltd in November 1988. This traffic study provided existing AADT for all major road routes entering Northam and enabled projections to be made for traffic volumes after construction of the bypass. In 1996, MRWA commissioned Halpern Glick Maunsell to develop the Master Plan for the Northam Bypass and to update the Uloth and Associates (1988) traffic study.

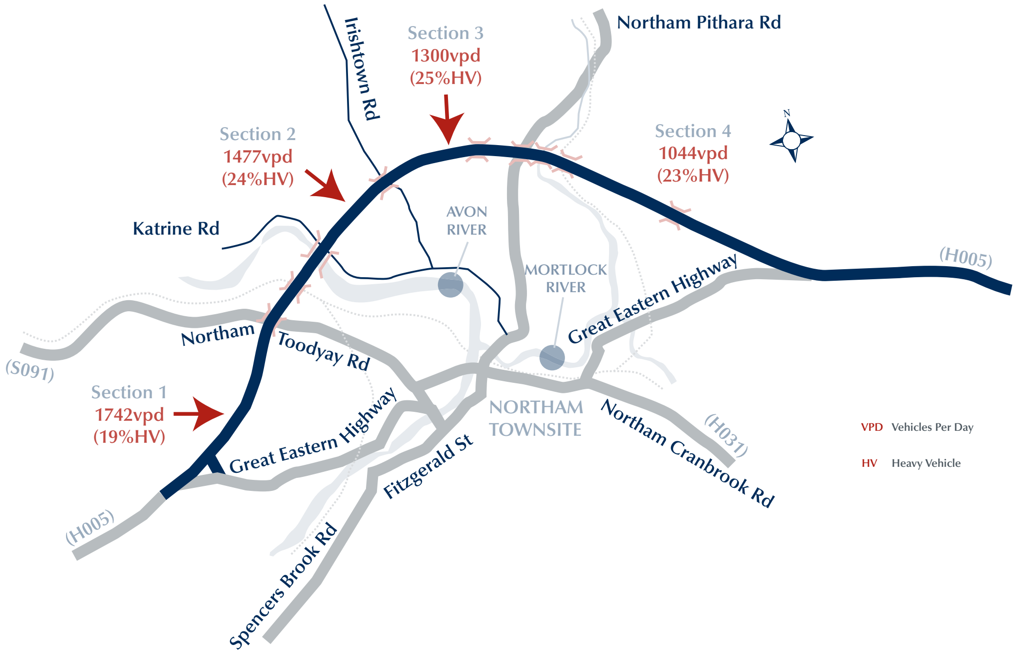
For economic evaluation of a bypass project, normally, two types of traffic information are of interest: first, total traffic on the Northam townsite route; and second, through traffic expected to use the bypass. For the total traffic, the Stage 3 PPR stated:

> "Serious congestion occurs in Fitzgerald Street, which has an AADT of approximately 7000 vehicles per day (vpd), of which approximately 5% are heavy vehicles" (MRWA, March 1999, p. 5).

However, the Stage 3 PPR (MRWA 1999) did not report how traffic volumes varied within a day, thereby making it difficult to gauge how serious the congestion was at the time.

As for the through traffic that would use the bypass, MRWA (1999) relied on traffic forecasts derived from Halpern Glick Maunsell (1996), which indicated that, if the bypass had been operational in 2000, traffic volumes for the bypass would have ranged from 1044 vpd (Section 4, eastern end) to 1742 vpd (Section 1, western end) with a heavy vehicle content ranging from 19 to 25 per cent (Figure 3). Traffic using the bypass was reported to grow at 3 per cent per year (linear)[2] for the 30-year study period, with a heavy vehicle component ranging from 21 to 26 per cent.

Figure 3 Northam Bypass traffic forecasts (2000)



Source: MRWA (1999).

How accurate were these predictions?

In October 2003, MRWA commissioned SHAWMAC (2003a) to undertake a thorough analysis of traffic before and after the opening of the Northam Bypass. The study compared the findings from an earlier study, *Northam Bypass 'Before' Traffic Study* (Transcore, 2002), with those of a new study undertaken by (SHAWMAC 2003b), *Northam Bypass 'After' Traffic Study*. The traffic information collected for the SHAWMAC (2003b) study enabled us to compare the actual traffic volumes using the bypass in 2003 with those predicted in MRWA (1999). As seen in Table 4, the actual traffic volumes using the bypass in 2003 were overall higher than those predicted for various sections of the bypass (except for Section 1). This was especially so with heavy vehicle traffic, with shares higher than predicted for all sections.

2 In the input dataset used for the ex-ante evaluation of the Northam Bypass project, an average annual growth rate of 2 per cent (linear) was used for both the local and bypass traffic, not the reported 3 per cent.

Table 4 Traffic using the bypass: actual versus predicted

	AADT	*Variation*	*HV share*	*Number of HV*	*Variation*
2000 (predicted)					
Section 1 (western end)	1 742		0.19	331	
Section 2	1 477		0.24	354	
Section 3	1 300		0.25	325	
Section 4 (eastern end)	1 044		0.23	240	
2003 (predicted)					
Section 1 (western end)	1 899		0.19	361	
Section 2	1 610		0.24	386	
Section 3	1 417		0.25	354	
Section 4 (eastern end)	1 138		0.23	262	
2003 (actual)					
Section 1 (western end)	1 738	-8.5%	0.23	400	10.9%
Section 2	1 659	3.0%	0.25	413	6.96%
Section 3	1 583	11.7%	0.26	415	17.1%
Section 4 (eastern end)	1 463	28.6%	0.24	357	36.4%

Notes: Predicted traffic volumes (T) for 2000 were obtained from MRWA (1999), p.12; Predicted traffic volumes for 2003 were derived according to the formula: $T_{2003}=T_{2000}+(T_{2000}*0.03)*3$; Actual traffic volumes were taken from SHAWMAC (2003a); Variation is actual values for 2003 divided by predicted values, minus one, expressed as a percentage.

Source: MRWA (1999), p.12; SHAWMAC (2003a).

Road user benefit estimation

The MRWA (1999) study considered four areas of potential savings for road users as a result of the bypass project. These were:

- Travel time savings;
- Savings in vehicle operating costs (VOCs);
- Accident cost savings; and
- Savings to the freight industry.

The first three components were modelled in RURAL3. Savings to the freight industry were derived outside the RURAL3 program.

Non-road user benefits such as noise and pollution reductions were qualitatively discussed, but not quantitatively estimated by MRWA (1999).

Travel time savings

According to MRWA (1999), travel time savings as a result of the bypass would be $31.7m in present value terms, representing 49.2 per cent of the total road user benefits (Table 3). It was not clear how benefits of this magnitude would accrue. This result was queried by the Technical Services Group within the then Roads Program Branch of DOTARS:

> " ... time savings are valued at $31.7m (PV), suggesting an annual reduction in travel time cost of about $2m. This indicates a time saving of about 12 minutes per trip, and 20 minutes for travelling through Northam on the existing road at an average speed of just 33 km/h. This does not seem realistic. ... " (DOTARS file: L1999/1541, p. 23).

One key factor explaining why MRWA's estimate of travel time savings was so high was the way in which intersections were treated for the base case. The old GEH through the Northam townsite suffered serious problems with intersections. This was particularly true for heavy vehicles having to negotiate:

- four right angle turns at intersections (one signalised, two stop sign controlled);
- two at-grade railway crossings (one being the main east-west National Railway line); and
- one busy main street (Fitzgerald Street).

In the MRWA (1999) evaluation, extra lengths were added to various links to take into account effects of delay caused by these intersections in the base case. The issues revised by the Technical Services of Roads Program Branch suggested that this might have been overestimated.

With hindsight, it appears that the travel time savings due to the bypass have been overestimated. According to the post-completion review undertaken by SHAWMAC (2003a), travel time saved by traffic using the bypass was only around three and half minutes per trip. Travel time savings on the existing through-town route ranged only between 34 seconds (eastbound) and 52 seconds (westbound).

Savings in VOCs

According to MRWA (1999), savings in VOCs as a result of the bypass would be $19.6m in present value terms, which represents 30.5 per cent of the total road user benefits (Table 3). This result was also queried by the Technical Services of Roads Program Branch:

> " ..., as the bypass is about 2 km longer than the existing road, it is questionable how savings in vehicle operating costs can be nearly $20m (PV)" (DOTARS file: L1999/1541, p.23).

The reason for the high estimate of VOC savings was the same as for the overestimate of travel time savings—increases in the link lengths to allow for intersection delays.

Savings in crash costs

According to MRWA (1999), safety benefits as a result of the bypass would be $4.9m in present value terms, representing 7.6 per cent of the total road user benefits (Table 3).

The Stage 3 PPR submitted by MRWA (1999) provided a brief discussion of crash history for the Northam townsite. Table 5 reproduces crash data for 1985-1998 presented in MRWA (1999) together with those from the earlier studies (BSD 1995 and MRWA 1994).

As seen in Table 5, during the period from January 1985 to December 1998, a total of 483 crashes were recorded on the base case route, of which 5 were fatal, 109 resulted in serious injuries, 247 resulted in major property damage and 122 resulted in minor property damage. As for crash type, 28 per cent of the total crashes recorded were collisions at right angle, 19 per cent sideswipe accidents and 18 per cent rear end collisions

Table 5 Crash history for the Northam townsite (1985-1998)

	01/1985-05/1990 (BSD 1995)			*01/1985-12/1993 (MRWA 1994)*			*01/1985-12/1998 (MRWA 1999)*		
	Period total		No. of crashes per year	Period total		No. of crashes per year	Period total		No. of crashes per year
Total number of crashes	257		47.4	355		39.4	483		34.5
By Injury Type									
Fatal	2		0.37	3		0.33	5		0.36
Serious injuries	na		na	80		8.9	109		7.8
Major property damage	na		na	181		20.1	247		17.6
Minor property damage	na		na	91		10.1	122		8.7
By Crash Type		%			%			%	
Collisions at right angle	82	(32)	15.2	92	(26)	10.3	135	(28)	9.7
Sideswipe accidents	54	(21)	10.0	89	(25)	9.9	92	(19)	6.6
Rear end collisions	44	(17)	8.1	82	(23)	9.1	87	(18)	6.2
Non collision accidents	18	(7)	3.3	23	(6)	2.6	29	(6)	2.1
Other	59	(23)	10.9	69	(19)	7.7	140	(29)	10.0

na: Not available.

Source: BSD (1995), p. 6, MRWA (1994), p. 4 and MRWA (1999), p. 6.

MRWA (1999) indicated that 80 per cent of the total crashes had occurred on straight and level sections of GEH/Fitzgerald Street and argued that this had been mainly a result of the congestion on the road and conflict between local and through traffic.

The argument about congestion and conflict between local and through traffic being the key contributors to accidents was not supported by data. As shown in Table 5, the overall crash rate (number of crashes per year) saw a trend of continuous decline during 1985-1998, despite increasing traffic in Northam. The annual number of collisions at right angles, which was of special concern, also trended downwards during the period.

The MRWA (1999) report claimed that the project would reduce the crash rates by half, from 0.68/MVKT (the State average) to 0.34/MVKT. However, it appeared that in the actual project evaluation, MRWA used the RURAL3 default crash rates for the Model Road States of the 63 modelled links for both the base and project cases. The high value for the safety benefits was influenced by the increased road lengths for the base case.

Additional travel time cost and VOC savings for the freight industry

In addition to the standard road user benefits, MRWA (1999) argued that the project would enable the development of a road train assembly area closer to Perth. As a result, there would be savings in travel time and VOCs (estimated to be $8m in present value terms) from the reduced distance travelled by shuttle vehicles. The stage 3 PPR did not report how the $8m savings were derived nor did it show that the Northam Bypass project was solely responsible for their realisation.

The additional travel time cost and VOC savings for the freight industry, as alluded to in MRWA (1999), have not been realised because no change has taken place in the location of the road train assembly area since the completion of the project.

Non-road user benefits

MRWA (1999) discussed qualitatively non-road user benefits such as noise and pollution reductions, but did not estimate them quantitatively. This could lead to an underestimation of benefits.

SHAWMAC (2003a) showed that, in 2003, around 1600 vehicles a day were taken out of the Northam townsite route by the bypass. The decreased traffic through Northam resulted in a reduction in noise and possibly an improvement in air quality in Northam.

Chapter 4 Methodological issues in ex-post evaluation

A number of methodological issues in relation to this case study are discussed below.

Treatment of intersections

The WARES system was developed for analysing open road conditions and has no allowance for the effect of intersections. There were quite a few intersections in the Northam townsite affecting the flow of GEH traffic through the town. In order to capture the delay effects caused by these intersections, the MRWA (1999) evaluation increased the length of the base case townsite route by 69 per cent, from 13.6km to 23.0km.[3] While this approach was intended to address the issue of the base case traffic delay caused by intersections, it distorted the calculation of VOCs and crash costs.

The MRWA's analysis of effects of intersections on traffic delay could have been done in other ways. For example, data and resources permitting, the delay effects could have been formally modelled by using a computer program such as SIDRA[4]. In case of data and resource constraints, explicit assumptions could have been made about the number of stops and the average delay of each stop for the base case. Sensitivity testing could have been undertaken to show the effects on results of a range of delay assumptions.

For the ex-post evaluation in this case study, no formal intersection modelling was undertaken, nor was there any a need to do so. This was because SHAWMAC (2003a) provided information on 'before' and 'after' actual trip times for both the bypass route and through-town route, and the derived actual travel speeds for the base case route could be used as a basis to formulate a change in the speed limits. Reducing speed limits in WARES suppresses the maximum speeds along the main streets, which serves as a proxy for impedance caused by intersections.

The presence of intersections in the through-town route would cause stop/start conditions for traffic, which would add to VOCs in the base case. Such effects could have been modelled separately if the required information had been available. Because there was no readily available information on the average VOCs per stop, this ex-post evaluation was unable to estimate the additional VOCs caused by intersections for the base case. This would lead to an underestimation of VOC savings in the ex-post evaluation.

3 According to the WARES User Manual (MRWA 1995), the cost of intersection delays can be approximated by adding 150 metres to every link approaching signals and 250 metres to every link approaching a stop or giveway sign.

4 Signalised & Unsignalised Intersection Design and Research Aid.

Traffic updates

Road user cost savings due to the Northam Bypass project apply to the through and other traffic using the bypass and the local traffic. Through traffic using the bypass can travel at a higher speed (though a longer distance) compared with the through-town route. Traffic from other routes using the bypass can possibly travel shorter distances at faster speeds. Local traffic on the through-town route can also travel faster because of reduced congestion. The size of the total travel time savings depends on the amount of traffic diverting to the bypass and the subsequent reduction in congestion on the Northam townsite route.

Updating traffic information for this ex-post evaluation was a substantial task because of the number of links involved. The focus of our update was on the following three areas:

- correcting inconsistencies between diverted and bypass traffic;
- updating traffic levels; and
- revising traffic growth forecasts.

Correcting inconsistencies in bypass traffic data

There appeared to be some inconsistencies in the bypass traffic data used in the ex-ante analysis.

Predicted traffic using the bypass

The predicted traffic using the bypass for 2000 is summarised in Table 6. On average (distance-weighted), 972 vehicles were expected to use the bypass per day. It should be noted that the predicted bypass traffic levels presented in Table 6 were not consistent with those reported in MRWA (1999). One possible reason for this inconsistency was that, in the input dataset, the growth rate of the bypass traffic was specified to be 2 per cent per annum (linear), rather than 3 per cent per annum (linear) as indicated in MRWA (1999).

Table 6 Predicted traffic using the Northam Bypass (2000)

Link No.	*Bypass route*	*Section length (km)*	*AADT (2000)*	*Speed limit (km/h)*
1	RED1	3.2	982	110
2	RED1	0.1	1 016	110
3	RED1	2.6	1 016	110
4	RED1	2.5	1 011	110
5	RED1	3.5	903	110
6	RED1	3.3	903	110
Total		15.2	972	110

Source: Input data for RURAL3.

Predicted traffic diverted from the townsite route

Predicted traffic diverted from the townsite route is summarised in Table 7. Except for Section 4 of the bypass route and Section 16 of the townsite route, traffic data reported in Tables 6 and 7 are consistent.

Table 7 Predicted traffic diverted from the townsite route (2000)

Link No.	*Townsite route*	*Section length (km)*	*AADT (2000)*	*Speed limit (km/h) (weighted average)*
1	H005	0.7	982	100
2–9	H005	3.8	982	80
10	H005	0.1	982	60
11–15	H005	2.1	1 016	41
16	H005	1.0	1 035	60
17	H005	0.4	903	70
18–20	H005	1.8	903	73
21–33	H005	4.7	903	97
Total		14.6	963	68

Source: Input data for RURAL3.

Predicted traffic diverted from other routes

Predicted traffic diverted from other routes is summarised in Table 8.

Combining the traffic data reported in Tables 7 and 8 revealed a mismatch between the total bypass traffic (Table 6) and the traffic diverted from the townsite and other routes (Tables 7 and 8). The effect would be an underestimation of road user costs for the project case. This error was corrected in the ex-post evaluation by adding the traffic diverted from other routes to the total bypass traffic.

Table 8 Predicted traffic diverted from other routes (2000)

Link No.	*Townsite route*	*Section length (km)*	*AADT (2000)*	*Speed limit (km/h) (weighted average)*
1–4	M032	2.0	145	60
5–8	M032	1.1	128	60
9	M032	0.4	0	60
10–11	M031	0.6	0	80
12–15	M031	1.3	0	100
16	S091	0.3	98	60
17–22	S091	2.4	98	65
23–24	L110	6.0	9	60
Total		14.3	60	66

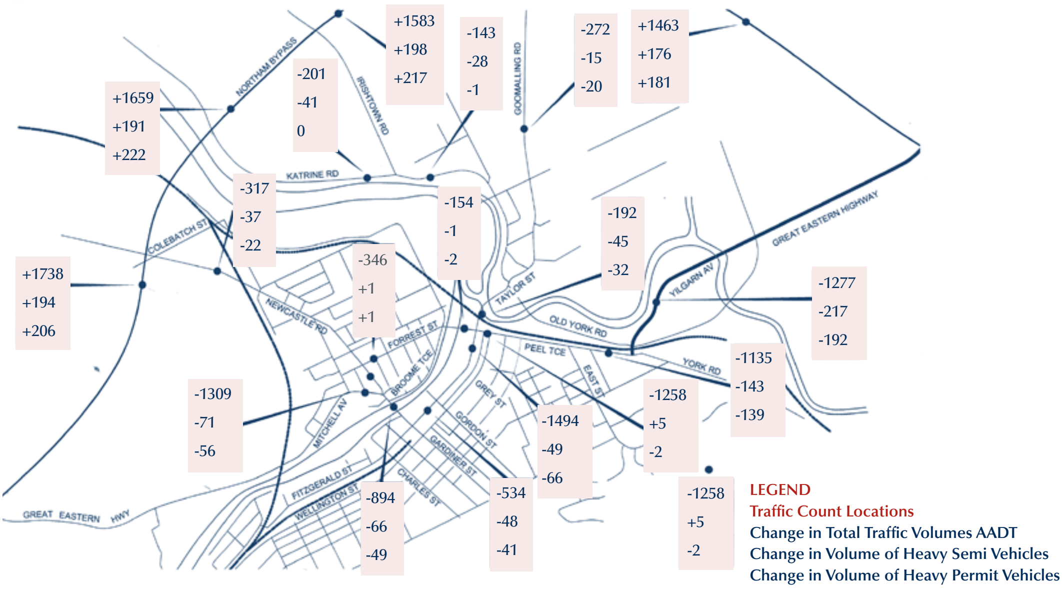
Source: Input data for RURAL3.

Updating bypass traffic levels

As mentioned earlier, bypass traffic levels were underestimated in the ex-ante analysis (Table 4).

In 2003, SHAWMAC (2003a) undertook a review of traffic at Northam before and after the construction of the bypass. Figure 4 reports the findings of the SHAWMAC study (2003a).

Figure 4 Changes in traffic counts (2003 versus 2002)



Source: SHAWMAC (2003a).

A number of conclusions emerge from Figure 4.

- On average, around 1600 vehicles were taken out of the Northam townsite routes per day;
- Of these 1600 vehicles, around 1300 were from the through-town section of the GEH; and
- The remaining 300 vehicles were from the other routes in the Northam townsite.

The results of the SHAWMAC (2003a) study were used as a basis to make necessary adjustments to the base-year traffic data. The purpose of these adjustments was to bring the model-estimated bypass traffic levels into line with the actual levels.

Revising traffic growth forecasts

In the input dataset used for the evaluation of the Northam Bypass project, the traffic growth rate was assumed to be 2 per cent per annum (linear) for all links. This was inconsistent with MRWA (1999). For the ex-post evaluation, different growth rates were assumed for the local and through (bypass) traffic. Based on discussions with MRWA, it was assumed that, for the whole evaluation period, the bypass traffic would grow at 3 per cent per annum (linear) and local traffic at 1.5 per cent per annum (linear).

Road user cost estimation

The MRWA (1999) study used RURAL3 (an earlier version of the RURAL program) to model road user costs, including travel time costs, vehicle operating costs and crash costs. For this case study, the same computer program was used to reconstruct the original analysis and to undertake the ex-post evaluation.

Ideally, RURAL8, which is the most recent version of the RURAL program, should have been used for the ex-post evaluation in this case study because it represents the best appraisal tool available in WA. Use of RURAL8 would, however, require a change to be made to the complex structure of the original input dataset which had 63 links and nearly 80 variables. Making such a change would be a very tedious process, which risks introducing errors.

Use of RURAL3 for the ex-post evaluation in this case study limited the scope of the analysis in some ways. Many of the model parameters (for example unit road user costs) were hard-coded and any change to these parameters would require the software to be recompiled.

Crash analysis

So far, there has been no review of crash statistics since the completion of the Northam Bypass project. The SHAWMAC (2003a) study did not collect any crash data to show the actual safety performance of the Northam Bypass project. This was mainly because at the time when the SHAWMAC (2003a) study was undertaken, the Northam Bypass had been open for less than 18 months. This time period was not long enough to provide good estimates of long-term crash rates.

Updating crash data was complicated by the fact that crash information would have to be compiled for all the 63 links modelled in RURAL3 for both the base and the project cases. Because crash information was not available, this case study was unable to compare the predicted and actual safety performances of the project.

Project costs

The accuracy of project cost estimates is determined by comparing actual costs and estimated costs. The latter is defined as budgeted/forecast construction costs *at the time of decision to build*. The actual construction costs were obtained from DOTARS Project Payment Transaction Reports and MRWA Annual Reports for the relevant years.

Impact valuation

Austroads (2006) provides the most recent estimates of unit values for travel time, VOCs and crash costs. In terms of valuation errors, our focus was mainly on safety, because this was an area in which large changes in valuation have occurred over the past decade. The unit value of the crash cost currently used by MRWA was re-adjusted to 1998 dollar value and was used to update the estimated safety benifits.

Avoided externality costs

Herring Storer Acoustics (quoted through SHAWMAC 2003a) carried out a noise modelling study to quantify the noise levels for residences in the Northam townsite both before and after the opening of the bypass. The studies indicated that the reduction in the noise levels was typically of the order of 5 dB(A). The reduction in noise was found to be greater on weekdays when compared with weekends, probably due to a lower percentage of heavy vehicles on the weekends.

There are a number of methods of valuing noise disturbance. The simplest method is the generic approach recommended by Austroads (2006). This would involve a calculation of the reduced vehicle-kilometres travelled in the Northam townsite and application of a unit value of noise costs (cents per vehicle-kilometres travelled) to give an estimate of avoided noise costs. This approach does not appear to be suitable because of its generic nature and significant uncertainty in the recommended parameters.

A sophisticated approach would be to use the hedonic price technique, which takes the impact on house prices as a proxy for the willingness to pay for peace and quiet (RTA 1999). However, this requires a significant amount of new data to be collected, which is beyond our present capability in terms of both time and costs.

An air quality comparison was undertaken by GHD (quoted through SHAWMAC 2003a) from the data collected by Ecotech Pty Ltd during 6-25 February 2002 and between 17 February and 3 March 2003 at Fitzgerald Street and Forrest Street in Northam. The study found that there was an improvement in air quality following the opening of the Northam Bypass. However, the study noted that improvement was likely to have been caused by reductions in local pollutant sources.

Other impacts

The urban environment in Northam (particularly Fitzgerald St) has improved noticeably thanks to the redirection of heavy vehicle traffic away from the town centre as a result of the bypass. It was noted (study tour 2006) that the street had been narrowed, speed humps placed along its length resulting in a safer environment, and public art was being developed in off-street Mall areas. It was also noted that cafés and restaurants were offering "side walk" dinning. These changes appeared to have encouraged social interaction and created a more intimate shopping experience for local residents as well as enhancing the town's tourism attraction.

However, assessment of these impacts was not undertaken because of a lack of clear guidelines and a need to collect a significant amount of new data.

Base and price year

For this case study, the base and price year was set at 1998. All the construction and maintenance costs that occurred prior to 2002 were converted to 1998 dollar values by using appropriate road cost indices.

Discount rate

The discount rate used for economic evaluation of National Highway projects (or the required rate of return) has been 7 per cent for many years. Historically, the justification for such a high discount rate may have been linked to the Capital Asset Pricing Model used by financial analysts. In this model, an allowance for risk is made by adding a risk premium to the risk free rate of return.

Since the publication of BTE Report 100 (BTE 1999), *Facts and Furphies in Benefit-Cost Analysis: Transport*, the BTRE has been promoting use of lower discount rates for appraisal of public infrastructure projects. BTRE's latest publication on this matter is Report 110: *Risk in Cost-Benefit Analysis* (BTRE 2005). The report argues that adding a risk premium to the risk free rate is not an effective way to deal with uncertainty and risks for appraisal of public sector projects except under very restrictive assumptions that are unlikely to hold in practice. It has been suggested that the government, inflation-free, bond rate (currently around 3 per cent) should be used when carrying out analyses of projects with widespread impacts. Risk should be taken into account by developing alternative forecasts for individual costs and benefits, with probabilities attached. Expected values of BCA results can then be estimated.

While the discount rate to use in ex-ante project appraisals can be debated, this ex-post economic evaluation has been undertaken using a 7 per cent discount rate and a risk-free discount rate. Once a project has been completed and in operation, there is little risk left. Major construction is over and traffic flows have largely stabilised, although it may be some time before representative crash rates for the project case can be effectively evaluated. The outcomes based on a discount rate with and without a risk premium can then be compared against each other to show the variation in the evaluation results due to a change in the discount rate.

Chapter 5 Reconstruction of the ex-ante analysis

The first step in any ex-post evaluation is to reconstruct the original BCA analysis, as it forms the basis against which results of ex-post evaluation can be compared.

RURAL3 (November 1997 version), which belongs to the WARES suite of models, was used to replicate the MRWA (1999) analysis. RURAL is one of the Austroads-harmonised rural road evaluation models (Austroads 2005). The original input data was supplied by MRWA.

Table 6 presents the results of the reconstructed MRWA (1999) analysis. There are some differences in results between the original and reconstructed analyses.

Table 9 Reconstructed MRWA (1999) results

($m, in 1998 prices)	*MRWA (1999) (A)*	*RURAL3 Replication (B)*	*% (A/B-1)*100*
Discounted benefits	**64.33**	**64.27**	**0.1**
Travel time	31.66	31.24	1.3
VOC	19.64	20.22	-2.9
Safety benefit	4.90	4.64	5.5
Savings in maintenance costs	0.13	0.16	-17.8
Other benefits (freight)	8.00	8.00	0.0
Discounted costs	**47.02**	**39.70**	**18.40**
Project costs	47.02	39.70	18.4
NPV	**17.31**	**24.57**	**-29.5**
BCR	**1.37**	**1.62**	**-15.5**

Source: MRWA (1999), p.18, BTRE estimates.

On the benefit side, there are some minor discrepancies between the estimated savings in road user costs, which may be caused by a different version of RURAL3 being used for the replication. For savings in maintenance costs, while the difference in percentage terms is large (-17.8 per cent), the absolute difference is quite small (less than $0.03m).

On the cost side, the discounted capital costs were estimated to be lower in the reconstructed analysis. The $39.7m discounted capital costs were derived on the basis of the time profiles of expenditure predicted in Stage 3 PPR (MRWA 1999). The original analysis did not discount the construction costs leading to overestimation of project costs by 18.4 per cent.

Overall, the NPV estimated in the reconstructed analysis was $7.3m higher, almost entirely due to the lower discounted capital costs.

Chapter 6 Ex-post evaluation results

In this section, the results of adjustments made to a number of key variables of interest in the reconstructed MRWA (1999) analysis are reported. These adjustments were to:

E1. improve the treatment of intersection effects;

E2. remove savings to the freight industry;

E3. change the construction costs and project timing;

E4. change the traffic levels and growth;

E5. change the unit crash cost; and

E6. change the discount rate.

The number of adjustments introduced in this ex-post evaluation was fewer than for the other case studies in this series. The normal freight time savings were not estimated due to the limitation of RURAL3. Because of the complex nature of the Northam road network and the amount of information required, changes in vehicle composition and crash rates were not updated for the ex-post evaluation in this case study.

Improved treatment of intersection effects (E1)

As mentioned earlier, the MRWA (1999) study increased the inventory road length to take into account the delay effects caused by intersections in the Northam townsite route. This approach led to an overestimation of travel time (or underestimation of travel speed) for the base case.

The improved approach adopted in this ex-post evaluation was to control the average speeds through changes in posted speed limits rather than distance. The new approach comprised the following elements:

- reduce the increased townsite-route road length to the actual length, that was, from 23km to 14.6km;
- use the results of the SHAWMAC (2003a) study to derive the average travel speeds for the base and project cases that were consistent with the actual travel time savings for the bypass traffic (-3.5 minutes) and local traffic (-0.5 minutes); and
- impose the newly derived average travel speeds through a change in the posted speed limits in the original RURAL3 input dataset.

Table 10 presents the assumptions used in this adjustment. The assumption about the base case travel speed for the through-town route became more reasonable—an average of 69 km/h compared with the implied 33 km/h in the original analysis. The project-case speed for the through-town route was assumed to be 72 km/h and for the bypass route 99 km/h.

Due to lack of information, the travel speeds for other routes were, however, set in an *ad hoc* way, assuming a travel time saving of up to 0.5 minute.

Table 10 Assumptions about travel speeds

	Distance (km)	*$Speed_{base}$ (km/h)*	*$Speed_{project}$ (km/h)*	*$Time_{base}$ (minutes)*	*$Time_{project}$ (minutes)*	*Savings in travel time (minutes)*
Through-town route	14.6	69	72	12.7	12.2	0.5
Other routes	14.3	61	63	14.0	13.5	0.5
Bypass route	15.2		99[a]		9.2	3.5

a The original assumption was 90 km/h. Based on SHAWMAC (2003a), the derived estimate should be 102 km/h. Due to a limitation of RURAL3, it was set to 99 km/h. A corresponding adjustment was made to the average speed for the through-town route so that the 3.5 minute saving in travel time was maintained.

Source: BTRE estimates based on SHAWMAC (2003a).

Table 11 presents the economic evaluation results using the new method of treating the delay effects caused by intersections. The total user benefits were overestimated in the original analysis by $34.8m or 118.4 per cent. Most of this overestimation came from VOC savings ($17.6m) and travel time savings ($14.5m). The new estimate for the VOC savings is only $2.7m.[5] This result is not surprising given that the bypass route is slightly longer than the normal route. The revised estimate for the travel time savings ($16.8m) is only 53.7 per cent of the original estimate, because the average speed for the base case assumed in the original analysis was less than half of the speed assumed in this adjustment. The reduced estimate for crash cost savings was due to the reduction in the road lengths for the base case.

Overall, using the improved methodology for treating the intersection effects led to a negative NPV (-$10.3m) and a BCR of 0.74.

Table 11 Improved treatment of intersection effects

($m, in 1998 prices)	*RURAL3 Replication (RA) (A)*	*Improved treatment of intersection effects (E1) (B)*	*% (A/B-1)*100*
Discounted benefits	**64.27**	**29.43**	**118.4**
Travel time	31.24	16.77	86.3
VOC	20.22	2.67	656.5
Safety benefit	4.64	1.97	136.2
Savings in maintenance costs	0.16	0.02	647.6
Other benefits (freight)	8.00	8.00	0.0
Discounted costs	**39.70**	**39.70**	**0.0**
Project costs	39.70	39.70	0.0
NPV	**24.57**	**-10.27**	**na**
BCR	**1.62**	**0.74**	**118.4**

na: not applicable.

Source: BTRE estimates.

5 This estimate could have been higher if the effects on VOCs of stop–start conditions caused by intersections had been modelled.

Removing savings to the freight industry (E2)

The next adjustment was to remove the $8m in savings to the freight industry, because they have never been realised. The effect was a further decline in the estimated BCR, from 0.74 to 0.54 (Table 12).

Table 12 Removing freight benefit

($m, in 1998 prices)	*RA plus E1 (A)*	*Removing freight benefit (E2) (B)*	*% (A/B-1)*100*
Discounted benefits	**29.43**	**21.43**	**37.3**
Travel time	16.77	16.77	0.0
VOC	2.67	2.67	0.0
Safety benefit	1.97	1.97	0.0
Savings in maintenance costs	0.02	0.02	0.0
Other benefits (freight-related)	8.00	0.00	na
Discounted costs	**39.70**	**39.70**	**0.0**
Project costs	39.70	39.70	0.0
NPV	**-10.27**	**-18.27**	**na**
BCR	**0.74**	**0.54**	**37.3**

na: not applicable.
Source: BTRE estimates.

Change in construction costs and timing (E3)

The actual nominal construction cost for the project was $49.4m which was equivalent to $43.2m in 1998 prices[6]. This represented an 8.2 per cent reduction below the originally budgeted cost of $47.0m. Because there was a postponement in implementing the project, the actual discounted capital costs were even lower ($34.6m, Table 13).

The original analysis assumed 1999 to be the first benefit year. Because the bypass was not opened until in May 2002, the first benefit year had to be pushed back by three years. As a result, the benefits for three of the more recent years were lost, with a consequent reduction in the present value of estimated road user benefits.

To maintain a 30-year analysis period after the completion of the project, the total length of the evaluation period was increased from 30 to 33 years. This change compensated for some of the lost benefits of the first three years.

Table 13 presents the results of the change in construction costs and project timing on the evaluation outcome. The reduction in capital costs more than offsets the reduction in road user benefits by a small amount. As a result, the NPV increased slightly from -$18.3m to -$16.0m with negligible change in the BCR.

6 Derived by using the BTRE Road Cost Index.

Table 13 Change in construction costs and timing

($m, in 1998 prices)	RA plus E1 and E2 (A)	Change in costs and project timing (E3) (B)	% (A/B-1)*100
Discounted benefits	**21.43**	**18.61**	**15.2**
Travel time	16.77	14.32	17.1
VOC	2.67	2.60	3.0
Safety benefit	1.97	1.67	17.4
Savings in maintenance costs	0.02	0.01	50.0
Other benefits (freight-related)	0.00	0.00	0.0
Discounted costs	**39.70**	**34.62**	**14.7**
Project costs	39.70	34.62	14.7
NPV	**-18.27**	**-16.01**	**na**
BCR	**0.54**	**0.54**	**0.4**

na: not applicable.
Source: BTRE estimates.

Change in traffic levels and growth (E4)

The corrections made in this adjustment included:

- making the bypass traffic flows consistent with the traffic flows diverted from the Northam townsite routes;
- bringing the level of the bypass traffic into line with observed bypass traffic flows; and
- using updated traffic growth forecasts, that is, 3 per cent per annum for the bypass traffic and 1.5 per cent per annum for the local traffic (compared with a uniform 2 per cent per annum in the original analysis).

Table 14 presents the impact of these corrections on the economic evaluation outcome. The estimated travel time savings increased by $2.7m largely reflecting a higher level of use of the bypass. VOC savings decreased, possibly due to faster travelling speeds on the bypass. The increased safety benefits might be associated with a shift of traffic from a low standard road (townsite routes) to a high standard road (bypass).

Adjustments to traffic data led to an increase in BCR from 0.54 to 0.60.

Table 14 Change in traffic levels and growth

($m, in 1998 prices)	*RA plus E1, E2 and E3 (A)*	*Change in traffic (E4) (B)*	*% (A/B-1)*100*
Discounted benefits	**18.61**	**20.72**	**-10.2**
Travel time	14.32	17.00	-15.7
VOC	2.60	1.66	56.6
Safety benefit	1.67	2.04	-17.9
Savings in maintenance costs	0.01	0.02	-41.7
Other benefits (freight-related)	0.00	0.00	0.0
Discounted costs	**34.62**	**34.62**	**0.0**
Project costs	34.62	34.62	0.0
NPV	**-16.01**	**-13.90**	**na**
BCR	**0.54**	**0.60**	**-10.2**

na: not applicable.
Source: BTRE estimates.

Change in unit crash cost (E5)

In the reconstructed MRWA (1999) analysis, the unit crash cost was assumed to be $65 000. The current default value for RURAL8 (based on Autroads' recommendation) is $75 717 (in 2000 prices), which is equivalent to $72 597 in 1998 prices[7]. As expected, use of a higher unit crash cost value led to an increase (11.8 per cent) in the estimated safety benefits (Table 15). However, the BCR changed little, due to the small share of safety benefits in total benefits.

Table 15 Change in unit crash cost

($m, in 1998 prices)	*RA plus E1, E2, E3 and E4 (A)*	*Change in unit crash cost (E5) (B)*	*% (A/B-1)*100*
Discounted benefits	**20.72**	**20.96**	**-1.1**
Travel time	17.00	17.00	0.0
VOC	1.66	1.66	0.0
Safety benefit	2.04	2.28	-10.5
Savings in maintenance costs	0.02	0.02	0.0
Other benefits (freight-related)	0.00	0.00	0.0
Discounted costs	**34.62**	**34.62**	**0.0**
Project costs	34.62	34.62	0.0
NPV	**-13.90**	**-13.66**	**na**
BCR	**0.60**	**0.61**	**-1.1**

na: not applicable.
Source: BTRE estimates.

7 Deflated by using the CPI.

Change in discount rate (E6)

The final adjustment was to change the discount rate from 7 to 3 per cent. The results are presented in Table 16. As expected, the BCA results improved, with the NPV increasing from -$13.7m to -$1.3m and the BCR from 0.61 to 0.97.

Table 16 Change in discount rate

($m, in 1998 prices)	*RA plus E1, E2, E3, E4 and E5 (A)*	*Change in discount rate (E6) (B)*	*% (A/B-1)*100*
Discounted benefits	**20.96**	**37.87**	**-44.7**
Travel time	17.00	30.57	-44.4
VOC	1.66	3.16	-47.5
Safety benefit	2.28	4.10	-44.5
Savings in maintenance costs	0.02	0.04	-35.1
Other benefits (freight-related)	0.00	0.00	0.0
Discounted costs	**34.62**	**39.17**	**-11.6**
Project costs	34.62	39.17	-11.6
NPV	**-13.66**	**-1.30**	**na**
BCR	**0.61**	**0.97**	**-37.4**

na: not applicable.
Source: BTRE estimates.

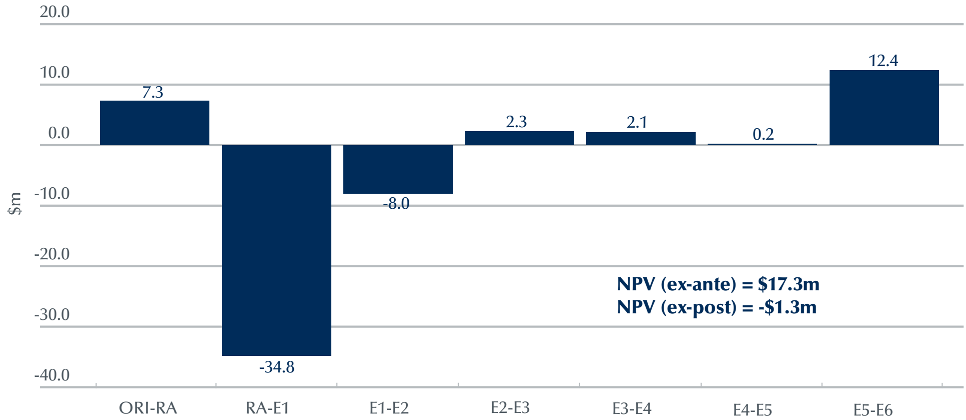
Bottom-line results

To bring together the ex-post evaluation results, the components of the total variation in NPV between the ex-ante and ex-post analyses are set out in Figure 5. The ex-post NPV was -$1.3m, $18.6m lower than the ex-ante estimate. The change in the treatment of the delays caused by intersections (RA-E1) contributed -$34.8m (or 187.1 per cent) to the total $18.6m difference in NPV. The variation in freight-related benefits (E1-E2) contributed -$8m (or 43.0 per cent).

Of the adjustments that led to an increase in the NPV, lowering the discount rate from 7 per cent to 3 per cent (E5-E6) was the most significant ($12.4m). Changing construction costs and project timing (E2-E3) increased the NPV by $2.3m. Improved traffic data and modelling (E3-E4) lifted the NPV by $2.1m.

The results of the ex-post evaluation reported in this section should not be viewed as the last word because there were a number of factors not updated or calculated, for example, changes in the traffic composition and crash rates, incorporation of the impact of intersections on VOCs savings, inclusion of the Austroads-recommended freight benefits and the improvement in local amenity.

Figure 5 Sources of variation in NPV



Keys:

ORI	=	Ex-ante BCA (MRWA 1999) - RURAL3
RA	=	Re-constructed MRWA (1999) analysis - RURAL3
E1	=	Improved treatment of intersection effects
E2	=	Removing freight benefits
E3	=	Change in construction costs and timing
E4	=	Change in traffic levels and growth
E5	=	Change in unit crash cost
E6	=	Change in discount rates

Chapter 7 Lessons learned

Several lessons can be drawn from the reconstruction of the original analysis and the ex-post evaluation.

Lessons learned from the reconstructed analysis (ORI-RA)

Documentation

While the Stage 3 PPR documented some of the WARES analysis, a much greater level of detail should be provided in the future, especially for a project costing tens of millions of dollars. There were a number of inconsistencies between the reported inputs and actual inputs, such as in road lengths, level of bypass traffic, traffic growth forecasts and crash rates. BCA inputs should be reported accurately so that results can be understood in the context of assumed inputs and the model used for evaluation. Increased accountability regarding BCA inputs should give decision makers increased confidence in the system to evaluate projects correctly.

Overestimation of discounted capital costs

The original analysis failed to apply any discounting to the construction costs leading to overestimation of the discounted project costs by 18 per cent.

Lessons learned from ex-post evaluation (RA-E6)

Treatment of delay effects caused by intersections

A major lesson drawn from this case study is about how intersections should be treated in the economic evaluation of a bypass project. In the ex-ante analysis, extra lengths were added to various links to take into account delay effects caused by intersections in the base case. This approach caused an underestimation of travel speeds for the base case and hence an overestimation of travel time savings. It also led to a large overestimation of savings in VOCs and crash costs.

A number of alternative approaches could be used to handle the effects of intersection delays. For the ex-post evaluation undertaken in this case study, reducing the maximum speeds through a change in the speed limits along the townsite route was used as a proxy for the impedance of intersections. This approach had two advantages compared with the approach used in the original analysis. First, working on speeds is a more direct approach, which could allow assumptions about speeds to be checked against the real world data. Second, it avoids major distortions in the calculated savings in VOCs and crash costs, although the effect on VOC savings of the stop-start nature of intersections is not captured.

In future town bypass evaluations, great care should be taken in selecting a methodology for modelling intersection delays for the base case. The adequacy of the assumptions made about travel speeds should be cross-checked against real-world observations, if possible.

Freight-related benefits

The ex-ante analysis included an $8m benefit to the freight industry in the form of savings in travel time costs and VOCs due to the reduced distance travelled by shuttle vehicles between Perth and the road train assembly area.

The construction of Northam Bypass was a necessary but not a sufficient condition for road trains to travel closer to Perth. Other complementary works, including the relocation of a road train assembly area, were required. If there were additional costs involved, they should have been included as part of the total project costs before any additional benefits could be claimed.

Traffic analysis

There were a number of anomalies in the traffic data used in the ex-ante analysis, causing road user benefits to be underestimated by around 10 per cent (Table 14).

Traffic analysis for a bypass project can be very complex. Because road user benefits are closely related to the estimated traffic levels and growth, good traffic analysis is important. Detailed documentation combined with a system of checks should help minimise errors made in traffic analysis.

Discount rate

At the time when the original analysis was undertaken, the specified discount rate for the economic evaluation of national highway projects funded by the Australian Government was 7 per cent. It was argued that for the ex-post evaluation, a 3 per cent (risk-free) discount rate is more appropriate. Based on this criterion, the economic viability of the Northam Bypass project was borderline, subject to further analysis of factors that have been omitted from this study.

Appendix A Chronological events

MM/YYYY	*Event*	*Prepared By /Source*	*Outcome/Findings*
09/1992	PPR S2 (v1) submitted	MRWA (1992)	Initial Stage 2 PPR based on route 6 (13.4 km).
11/1993	EPA report released	DoTARS file: L95/831, p. 33	Route 9 (15.7 km) determined as the environmentally acceptable route.
08/1994	PPR S2 (v2) submitted	MRWA (1994)	Revised Stage 2 PPR based on route 9 (15.7 km).
08/1995	$5m preconstruction fund approved	DoTARS file: L96/96, p.15	Over 3 years ending in 1997/98. To be used for: – route preservation; and – a more detailed assessment of the project.
10/1995	Northam Bypass Proposal released	Prepared by BSD Consultants, Pty Ltd	– Base case route = 13.1 km. – Project case route = 15.7 km.
02/1996	Halpern Glick Maunsell commissioned to develop the Master Plan and design and documentation	PPR S3, MRWA (1999)	– Develop the Master Plan for the Northam Bypass. – Proceed with preliminary and detailed design and documentation for construction.
03/1996	Value Management Study	DoTARS file: L96/96, p.120-3	To investigate: – the needs and timing of the bypass; and – ways in which costs could be minimised.
10/1996	Route 9 endorsed by the State Government	DoTARS file: L1999/1541	
11/1996	Funding approved by the Federal Government	DoTARS file: L1999/1541	Funded over a four year period commencing in 1999 and to be completed in 2002.
03/1999	PPR S3 submitted	GEH – Northam Bypass, MRWA	– Base case route = 13.6 km. – Project case route = 14.9 km.
05/1999	$40m funding announced by the Federal Government	DoTARS file: L1999/1541, pp.25-6	
08/1999	MRWA asked to cap the costs to $40m.	DoTARS file: L1999/1541, pp.34-5	
02/2000	State's commitment for project costs in excess of $40m	DoTARS file: L1999/1541	Estimated project cost revised down to $40.8m on the basis of more detailed information on the design.
06/2000	Environmental Assessment Review released	Environnent Australia DoTARS file: L1999/1541	No EIS required.
09/2000	PPR S3 approved	DoTARS file: L1999/1541	Funding approval granted at a capped amount of $40m.
01/2001	Construction contract awarded	DoTARS file: L1999/1541	
01/2001	Project started	DoTARS file: L1999/1541	
05/2002	Project completed	DoTARS file: L1999/1541	

Abbreviations

AADT	Average Annual Daily Traffic
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
BTE	Bureau of Transport Economics
BTRE	Bureau of Transport and Regional Economics
CPI	Consumer Price Index
DOTARD	Department of Transport and Regional Development
DOTARS	Department of Transport and Regional Services
GEH	Great Eastern Highway
MRWA	Main Roads Western Australia
MVKT	Million Vehicle Kilometres Travelled
NPV	Net Present Value
PPR	Project Proposal Report
PV	Present Values
RTA	Road and Traffic Authority (NSW)
RUC	Road User Costs
VOCs	Vehicle Operating Costs
VPD	Vehicles Per Day
WARES	Western Australian Road Evaluation System

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