Australian Government

Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Benefit-Cost Analysis Tool Guidance

April 2024

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Introduction

The Department of Infrastructure, Transport, Regional Development, Communications and the Arts (The department) recognises that the expense and time required to commission a detailed benefit-cost analysis may place a disproportional and excessive burden on non-state delivery agencies such as local governments for low value projects.

In December 2019, the department developed an excel-based tool to conduct rapid benefit-cost analyses and assist proponents to complete tables D2 and D4 of the Project Proposal Report (PPR) template. The tool is applicable to small road projects receiving a total Australian Government contribution up to $7.5 million.

After undertaking a wide range of benefit-cost analyses, it was deemed suitable to review the existing tool via an external consultancy. This review recommended further functionality through new inputs, whilst improving existing functions, and updating of reference values from the Australian Transport Assessment and Planning (ATAP) guidance. The tool was updated in September 2022 based on the review recommendations.

It is to be noted that the Benefit Cost Ratio (BCR) generated by the updated version of the tool may be slightly higher than the previous version as it is able to capture the costs and benefits of road projects with improved accuracy. The updated tool is also more convenient as it combines the Free Flow Model and Interrupted Flow Model into a single excel-based tool.

State delivery agencies should continue to use their own existing tools and processes rather than this tool, where they are likely to achieve more accurate outcomes.

Each individual transport problem and associated solution will be unique. Developing a generic tool which easily captures all relevant benefits with only a small number of required inputs will have inherent limitations compared to a detailed benefit-cost analysis. As such, modifications should be made as necessary to meet the specific needs of the initiative being analysed and this tool should not replace a detailed analysis where it is appropriate to do so.

The model has been developed to assess roads in two types of operating environments:

- **Free-flow** - applicable to speeds typically above 60km/h and applies to projects such as sealing/resealing rural or remote roads which enable faster travel time and reduction in vehicle operating costs due to significant reduction in roughness. Avoided maintenance and avoided diversions may also be major benefit drivers.
- **Interrupted flow** - applicable to speeds below 60km/h and applies to projects where travel time savings (TTS) accrue through reduced waiting times such as intersection upgrades (traffic lights, roundabouts and slip lanes), grade separations, etc. Accident reductions may also be a major benefit driver.

Within these operating environments, the tool also considers the project location (rural or urban) and the extent to which benefits are likely to be experienced (network wide or confined to a corridor):

- **Rural** - applicable to projects outside major metropolitan areas.
- **Urban** - applicable to projects inside metropolitan areas.
- **Corridor** - applicable to projects where costs and benefits are realised largely along a single road corridor and there is limited shift in traffic into or out of the corridor.
- **Network** - applicable to projects where the proposed changes result in costs and benefits distributed across a wider network area or where there is major rerouting of traffic due to the project.

Default Values and Limitations

The model and parameter values are based on current ATAP guidance, which have been simplified as much as possible. The model is not intended to replace a rigorous benefit-cost analysis. It aims to capture the majority of conventional benefits to derive an estimate of the BCR of a relatively low-value, generic road project.

In order to make the model and the process of inputting data as simple as possible, a number of default values have been chosen. For example, it is assumed that vehicles are either heavy or light. Operating cost parameters for heavy vehicles are based on a 6-axle articulated truck and a medium car for light vehicles. Other simplifications are explained at each section as appropriate.

Interface and Data Entry

The tool contains several tabs. Only the 'Input sheet' requires data entry (see Figure 1). All cells highlighted require data entry. Summarised instructions for each required input are contained within Columns C and D.

	C	D	E	F
1	Input Sheet			
2				
3				
4	Instructions	Category	Value	
5				
6	**Road Environment Type**	**Road Environment Type**		
7	Rural or Urban	Rural or Urban	Rural	
8	Free-flow (operating speed >60 km/h) or Interrupted (operating speed ≤60 km/h)	Free-flow or Interrupted	Free-Flow	
9				
10	**Project Discount Rate Data**	**Project Discount Rate Data**		
11	Select 4% or 7%	Discount Rate (%)	4%	
12	Assessment Year	Assessment Year (later than 2000)	2021	
13				
14	**Project Cost Data**	**Project Cost Data**		
15	Enter unescalated project capital cost including contingency (P50 or P90)	Capital Costs ($)	$ 100,000,000	
16				
17	**Economic Life of Project**	**Project Lifespan**		
18	Refer to Residual Value sheet to estimate economic life of project based on comp	Project Lifespan (yrs)	30	
19				
20	**General Project Data**	**Traffic Data**		
21	Select corridor or network project data for assessment	Corridor or Network Data	Corridor	
22	Enter actual or estimated AADT	Average Annual Daily Traffic (AADT, number)	1,000	
23	Estimate percentage of heavy vehicles	Heavy Vehicles (HV, %)	20%	
24	Estimate long term traffic growth	Annual Traffic Growth (%)	2%	
25	Basis of average speed calculation	Including/excluding intersection delay?	Excluding	
26	Estimate average speed under the base case	Base Case - Average Speed (km/hr)	70	
27	Estimate average speed under the project case	Project Case - Average Speed (km/hr)	70	
28	Enter project length	Project Length (km)	5	
29	Network Vehicle Kilometres Travelled (VKT) under the base case	VKT Not used for Corridor Assessment	100,000	
30	Network Vehicle Hours Travelled (VHT) under the base case	VHT Not used for Corridor Assessment	2,000	
31	Network Vehicle Kilometres Travelled (VKT) under the project case	VKT Not used for Corridor Assessment	100,000	
32	Network Vehicle Hours Travelled (VHT) under the project case	VHT Not used for Corridor Assessment	1,980	
33	Estimate the average level of roughness under the base case	Base Case - Roughness (IRI)	3	
34	Estimate the average level of roughness under the project case	Project Case - Roughness (IRI)	3	
35				
36	**Intersection Upgrade Travel Time Savings Data**	**Intersection Data**	**Number**	**Average Delay (Seconds per Intersecti**
37	Enter number of roundabouts and average delay - Base Case	Roundabouts	0	50
38	Enter number of signalised intersections and average delay - Base Case	Signalised	0	20
39	Enter number of unsignalised intersections and average delay - Base Case	Unsignalised	0	6
40	Enter number of other intersections and average delay - Base Case	Other Intersection (Level Crossings etc)	0	60
41	Enter number of roundabouts and average delay - Project Case	Roundabouts	0	25
42	Enter number of signalised intersections and average delay - Project Case	Signalised	0	10
43	Enter number of unsignalised intersections and average delay - Project Case	Unsignalised	0	3
44	Enter number of other intersections and average delay - Project Case	Other Intersection (Level Crossings etc)	0	30
45				
46	**Crash Savings**	**Crash Cost Data**		
47	Crash Data Period (minimum 5 years' data required)	Number of Years of Crash Data	15	
48	Enter number of fatalities experienced over the crash data period	Fatalities (actual or estimated number)	1	
49	Enter number of serious injuries experienced over the crash data period	Serious Injuries (actual or estimated number)	3	
50	Enter number of injuries experienced over the crash data period	Injuries (actual or estimated number)	4	
51	Estimate the reduction in crashes under the project case as a whole	Project Case - Estimated Reduction (%)	0%	
52				
53	**Road Closure (Diversion and Avoided Waiting Time) Savings**	**Diversion & Waiting Time Data**		
54	Additional distance travelled on diversionary route	Additional Distance Travelled on Diversionary Route (km)	5	
55	Enter average speed on diversionary route	Average speed on diversionary route (km/h)	70	
56	Estimate the average number of days the road is closed per year - Base	Base Case - Duration of Road Closures (days/year)	0	
57	Estimate proportion of vehicles diverting due to road closure - Base	Base Case - Proportion of Vehicles Diverting (%)	50%	
58	Calculated proportion of vehicles that decide not to travel due to road closure - Ba	Base Case - Proportion of Vehicles not Travelling (%)	50%	
59	Estimate the reduction in number of days the road is closed per year - Project	Project Case - Reduction in Road Closures (%)	100%	
60				

	I	J	L	M
4	Maintenance Costs - Project Case		Maintenance Costs - Base Case	
6	Maintenance Cost - Project Case ($)		Maintenance Cost - Base Case ($)	
7	Year	Value ($)	Year	Value ($)
8	1	11,000	1	10,000
9	2	11,000	2	10,000
10	3	11,000	3	10,000
11	4	11,000	4	10,000
12	5	11,000	5	10,000
13	6	11,000	6	10,000
14	7	11,000	7	10,000
15	8	11,000	8	10,000
16	9	11,000	9	10,000
17	10	11,000	10	10,000
18	11	11,000	11	10,000
19	12	11,000	12	10,000
20	13	11,000	13	10,000
21	14	11,000	14	10,000
22	15	11,000	15	10,000
23	16	11,000	16	10,000
24	17	11,000	17	10,000
25	18	11,000	18	10,000
26	19	11,000	19	10,000
27	20	11,000	20	10,000
28	21	11,000	21	10,000
29	22	11,000	22	10,000
30	23	11,000	23	10,000
31	24	11,000	24	10,000
32	25	11,000	25	10,000
33	26	11,000	26	10,000
34	27	11,000	27	10,000
35	28	11,000	28	10,000
36	29	11,000	29	10,000
37	30	11,000	30	10,000

Figure 1: 'Input sheet' tab within the Benefit-Cost Analysis tool.

Accurate or up to date data may not be available for fields such as traffic volumes, heavy vehicle/light vehicle split, road roughness, crash statistics, etc. In such instances an estimate should be used.

The 'Summary sheet' tab displays summary results (Figure 3), while the 'Table D4 PPR template' tab populates the data required to fill in section D4 of the PPR template and allows the user to copy and paste the data into the template.

D4 Benefit Net Present Value (NPV)

Benefit Component		Present Value of all Benefits ($m)	Year 10 Only: Year 10 Benefits in $m (10 years after construction complete)	Year 10 Benefits as a percentage of total benefits
Travel Time Savings	Total Travel Time Savings	n/a		
Reduced Vehicle Operating Costs (resource costs)	Total Reduced Operating Costs	$2.7m	$0.10m	7%
Crash Reduction	Total Crash Reduction	$10.8m	$0.40m	26%
Environmental Benefits	Total Environmental Benefits	$2.2m	$0.08m	5%
Other standard benefits (reliability, crowding, tolls/fare box)	Total Health Benefits	$24.8m	$0.91m	60%
	Total Avoided Infrastructure and Parking	$1.0m	$0.03m	2%
TOTAL STANDARD BENEFITS*		$41.5m	$1.52m	100%
Wider Economic Benefits	Agglomeration Benefits			
	Other Wider Economic Benefits			
	Total Wider Economic Benefits			
Other Benefits (i.e. City shaping)	(add category as required: such as heavy vehicle productivity)			
	(add category as required)			
	Total Other Benefits			

*Total Standard Benefits should equal sum of total benefits. |

Figure 2: 'Table D4 PPR Template' tab within the Benefit-Cost Analysis tool.

The model tabs are where calculations are performed in the background. These tabs should not be altered. All formulae are intact for transparency and traceability.

Several tabs are hidden which contain information such as default parameter values and references. They should also not be altered.

Road Environment Type

The 'Road Environment Type' section contains two key fields that determine which model and parameters are used for the assessment.

The first field contains 'Rural' or 'Urban' as selectable options. 'Rural' should be selected for all projects outside metropolitan areas, and 'Urban' for projects in metropolitan areas.

The second field contains 'Free-flow' or 'Interrupted' as selectable options. Interrupted flow may be experienced on urban and sub-urban arterials and freeways depending on factors such as time of day and traffic capacity.

The vehicle operating cost (VOC) threshold is approximately at 60km/h in the stop-start (interrupted) model and aggregate (free-flow) model. For travel speeds above 60km/h, use the free-flow version; and for speeds under 60km/h, use the interrupted version.

Project Discount Rate Data

The discount rate (4% or 7%) should be selected from the drop down.

The 'Assessment Year' defines the year that the costs and benefits will be indexed to.

Project Cost Data

Enter the un-escalated capital cost at Cell E15. The capital cost must include contingency (P50 and P90).

Maintenance Costs

This cost section refers to the difference between maintenance expenditure that would have occurred under the base case (note: would have occurred, not should have occurred) and the project case. For example, scheduled maintenance on a remote unsealed road may require it to be re-sheeted or regraded annually – these are maintenance costs that would occur. On the other hand, based on the road's condition, if a better course of action would be to provide an all-weather coating to eliminate the annual maintenance requirements, resulting in a reduction of the overall maintenance costs (a benefit) – these are changes that should occur (based on the road's condition) and would incorrectly understate the overall benefits associated with maintenance costs.

The estimated maintenance costs for the base case and project case (in assessment year dollars) should be entered in the years they are anticipated to be incurred in Columns M and J, respectively.

Economic Life of Project

The economic life of the project determines the residual value after the 30-year assessment period. Many road projects involving primarily pavement works will have an economic life of around 30 years, hence would not have significant residual values. However, some project components such as earthworks, bridges or drainage structures may have a much longer life (e.g. 50 years) and will have a residual value at the end of the assessment period, which must be accounted for. Refer to the 'Residual Value' tab for further information around economic life of project components.

Calculate and enter the economic life of the project based on the weighted value of project components (where available) in whole dollars.

General Project Data

General Project Data fields contain information on the current traffic volumes, speeds, project length and road surface. Not all fields are used in all models, and will be deactivated based on inputs.

Depending on the scale of project and its impact on the network, the assessment needs to be defined as either a 'Corridor' or 'Network' project as follows:

- 'Corridor' is applicable to projects where costs and benefits are realised largely along a single road corridor and there is limited shift in traffic into or out of the corridor
- 'Network' is applicable to projects where the proposed changes result in costs and benefits distributed across a wider network area or where there is major rerouting of traffic due to the project.

Estimated or known Average Annual Daily Traffic (AADT) should be entered at Cell E22. Because traffic volumes are likely to heavily influence total overall benefits, this value should be as accurate as possible. AADT is not required for Network assessments.

Enter heavy vehicle (HV) percentage at cell E23. For simplicity it is assumed that all HVs are 6-axle articulated with a GVM of 35.625 tonnes, assuming the truck weighs 15 tonnes and carries an average load of 20.625 tonnes (75% of the maximum 27.5 tonne load), as per ATAP recommendations.

Light vehicle (LV) percentage will automatically populate based on HV percentage. It is assumed that all LVs are medium cars with a GCM of 1.4 tonnes.

Annual traffic growth is set at a default of 2% per year. The growth rate can be adjusted at cell E24 if additional details around growth are known.

The 'Basis of average speed calculation' field allows two values, 'Including' and 'Excluding'. Set the field to 'Including' if the average travel speed includes the time spent queueing or stationary at intersections. Set the field to 'Excluding' if the average travel speed is based on signposted or free-flow speed and intersection delays will need to be entered separately. This field is not required for Network assessments.

In some cases, traffic speeds may increase as a result of an initiative, resulting in TTS. Estimates of average travel speed under the base case and project case should be made at cells E26 and E27 respectively. Average speeds are not required for Network assessments.

Project length is the length of the corridor being assessed, in kilometres. Length is not required for Network assessments.

Total Vehicle Kilometres Travelled (VKT) per day and Vehicle Hours Travelled (VHT) per day for the base case and project case should be entered in E29 to E32. VKT and VHT should be entered for all vehicle types across the assessment area, which should include all roads that have a change in traffic volume or travel speed due to the project. VKT and VHT are required only for Network assessments. It is anticipated that VKT and VHT will be generated by traffic models of the road project. Where VKT and VHT are not available from a traffic model, they can be approximated based on traffic volumes, travel distances and travel times on key roads in the study area. For example, VKT and VHT for a small network can be calculated by:

1. Defining key roads in the network (e.g. roads where traffic performance would change due to the project)
2. Estimating daily traffic volumes on each key road
3. Multiplying the length of each road (in kilometres) by the daily traffic volume to calculate VKT per road
4. Dividing the VKT per road by the operating speed or posted speed limit (in km/hr) to calculate VHT per road
5. Summing the individual road VKTs and VHTs to find the network VKT and VHT.

VKT and VHT must be calculated for base case and project case.

Users should enter the known or estimated value of roughness, in International Roughness Index (IRI), under the base case (or current condition) at Cell E33 and under the project case at Cell E34.

NAASRA Roughness Meter Counts (NRM) can be converted to IRI using the following formula:

$$IRI=(NRM+1.27)/26.49$$

If roughness data is not available, the fields can be set to ‘Not Available’ and the model will use an initial roughness of 2, deteriorating to 6 by year 30.

Roughness data is only required for the Rural Free-flow economic model.

Intersection Upgrade Travel Time Savings Data

To account for traffic-related time savings at intersections, users should enter the number of intersections (signalised, unsignalised, roundabouts, etc.) at Rows 37-44 and the estimated delays (in seconds) experienced at each one for the base and project case.

TTS will be calculated based on HV/LV split, number of vehicles, and the value of time associated with each vehicle type. Details of intersection performance are not required for Network assessments.

Crash Savings Data

Crash data is required for the project area (corridor or network) for at least five years. Cell E47 allows users to set the crash data period up to 15 years, but care must be taken to ensure that older crashes are still relevant to the project. For example, there may have been significant changes to the road environment, traffic volume or vehicle fleet over that timeframe, which could make historic crashes irrelevant to the current assessment.

From either crash data or estimates, enter the number of fatalities, serious injuries, and injuries that have occurred over the crash data period at Rows 48-50.

As a percentage, estimate the reduction in crashes as a result of the initiative at Cell E51.

Benefits as a result of crash reductions will be automatically averaged across the appraisal period.

Road Closure (Diversion and Avoided Waiting Time) Data

The Benefit-Cost Analysis tool uses a simplified method to calculate additional economic costs caused by road closures. In the model, the following options exist for motorists affected by closed roads:

- Divert (use an alternate route); or
- Do not travel.

Motorists may choose not to travel under circumstances such as due to flood warnings, advance notices of road works, etc. During periods of extended closures (more than a day), motorists will likely elect to either divert, or return to their place of origin.

At Cell E54 enter the additional distance travelled by a vehicle using the diversionary or alternative route, above the distance they would have travelled on the primary route.

At Cell E55 enter the estimated average speed of vehicles using the diversionary route.

At Cell E56 enter number of days the road is expected to be closed each year (on average) under the base case.

At cell E57 enter the proportion of vehicles diverting under the base case. Vehicles that are not diverting are assumed to not travel. Cell E58 automatically calculates the proportion of vehicles that do not travel.

At Cell E59 enter the percentage reduction in the number of days the road is expected to be closed each year (on average) under the project case compared to the base case (e.g. enter 100% if the proposed upgrades mean that there will be no road closures in the project case).

The model will calculate time and VOC savings achieved based on the number of vehicles that will no longer need to divert under the project case. There is no cost or benefit calculated for vehicles choosing not to travel, as it is assumed they will utilise their time in another way. Diversion and avoided waiting time details are not required for Network assessments.

Model Operation

Road Environment Type

The ‘Road Environment Type’ parameters define the economic model and cost values used in the assessment of a project. Four possible combinations are available as follows:

- Rural, Free-flow;
- Rural, Interrupted;
- Urban, Free-flow; and
- Urban, Interrupted.

Year of Indexation

All economic cost parameters (value of time, VOCs, crash costs, etc.) are indexed to the specified year using Consumer Price Index and Average Weekly Earnings data published by the Australian Bureau of Statistics. It should be noted that the latest year available for indexation is 2021 within the Benefit-Cost Analysis tool

Economic Costs

Capital costs in the model must include contingency (P50 or P90), and should be recorded in real dollars. Escalation costs should be excluded from the capital costs. Capital costs are not discounted and are assumed to be applied in a single year at the start of the project.

Maintenance costs are discounted using the entered discount rate (4% or 7%).

Economic Benefits

Avoided Cost of Maintenance is assumed to be a benefit, but could be a negative benefit in some cases where the project includes ongoing maintenance or operating costs, for example signalisation of a priority-controlled intersection or provision of a new road link.

Travel Time Savings arise from an increase in travel speed. For corridor projects these time savings are calculated using average travel speeds, project length, project volumes (AADT) and the value of time for light and heavy vehicles. For Network assessments, time savings are calculated from VHT and the value of time for the light and heavy vehicles.

Delay Reduction Savings arise from a decrease in delay at intersections, or the removal of intersections in the assessment area. These are calculated using the difference in intersection delays, project volumes (AADT) and the value of time for light and heavy vehicles. Delay reduction savings are not calculated for Network assessments, as intersection delays are included in total VHT.

Vehicle Operating Cost Savings are calculated differently for each road environment type. Rural, Free-flow VOC savings are primarily a function of roughness and speed. VOC savings as a result of reduced roughness[1] are partly offset by higher fuel costs if the project enables higher travel speeds.

ATAP prescribes using either the Australian Road Research Board (ARRB) aggregate model or the Alternative aggregate model to calculate VOC.

Because the ARRB aggregate model requires roughness, gradient, curvature and vehicle payload as inputs, the simpler Alternative aggregate model has been used for this tool which only requires speed and roughness.

VOC savings for other road environment types (Urban and Interrupted types) are based around a reduction in cost due to higher average travel speeds.

There are significant differences in VOCs across the 20 vehicle types recognised in the ATAP guidance. Base vehicle operating costs range from 21 cents per km for a small car to 190 cents for a Double B-Double. For simplicity this model assumes only 2 vehicle types – light vehicles or heavy vehicles (6-axle articulated).

Crash Cost Savings are calculated from the reduction in crashes due to the project. The assessment uses a flat reduction in crashes and assumes that the distribution of each crash type (fatal, serious injury and other injury) does not change after the project. The assessment uses different crash values for 'Urban' and 'Rural' road environments.

Road users may be faced with situations where roads are regularly closed due to flooding, periodic maintenance, or other factors (excluding congestion or delays from accidents) making a road impassable. This necessitates either not travelling or using an alternative longer route. This **Avoided Cost of Diversion** refers to avoided additional travel time/distance if an initiative mitigates such a transportation problem.

Costs of diversion also includes externalities. If part of a road is closed and a diversionary (longer) route is required, this results in externalities such as additional greenhouse gas emissions. Default values for externalities (rural and urban) expressed as cents per kilometre are embedded within the model.
Diversion costs are not separately calculated for Network assessments as they are included in total VKT and VHT values.

Residual Value of a project represents the value of project components at the end of the assessment period. Many road projects involving primarily pavements works will have an economic life of around 30 years, so these would not have significant residual value. However, some project components such as earthworks, bridges or drainage structure may have a much longer life and will still have value at the end of the assessment period.}

1. The rate with which a road deteriorates (measured as roughness) is dynamic and complex to model. It is affected by factors such as initial strength (and how well the pavement was constructed), traffic volumes and loadings, and moisture regime. Deterioration rate can be expected to follow a sigmoidal function over the design life of the pavement. However, there will be significant variances between segments and a 'typical' rate of deterioration in design life may also vary. For simplicity, this model assumes an exponential (rather than linear or sigmoidal) rate of deterioration, beginning slowly before accelerating towards the end of the 30-year appraisal period. As such, deterioration may be slightly understated. Conversely, it does not consider intervention treatments over the appraisal period (noting that sprayed seal treatments do not reduce roughness) that may reduce roughness. The two simplifications are expected to more or less balance themselves out.
As a rough guide, one may assume that the sealing of an unsealed road results in an initial roughness of 2, deteriorating to 6 by year 30. The roughness value is capped at 6, which is the assumed highest roughness in ATAP guidelines.

Outputs

The 'Summary sheet' tab provides a snapshot of the standard economic benefits for a range of categories, the net present value and the BCR.

Economic Costs	Value
Capital Costs	$9,373,494
Maintenance Costs	$0
Total Economic Costs	$9,373,494

Economic Benefits	Value
Avoided Cost of Maintenance	$0
Travel Time Savings	$195,364
Delay Reduction Savings	$0
Vehicle Operating Cost Savings	$1,043,483
Crash Cost Savings	$8,349,905
Avoided Costs of Diversion (including Externalities)	$342,515
Residual/Salvage Value	$0
Total Economic Benefits	$9,931,268
Net Present Value	$557,774
Benefit Cost Ratio (BCR)	1.06

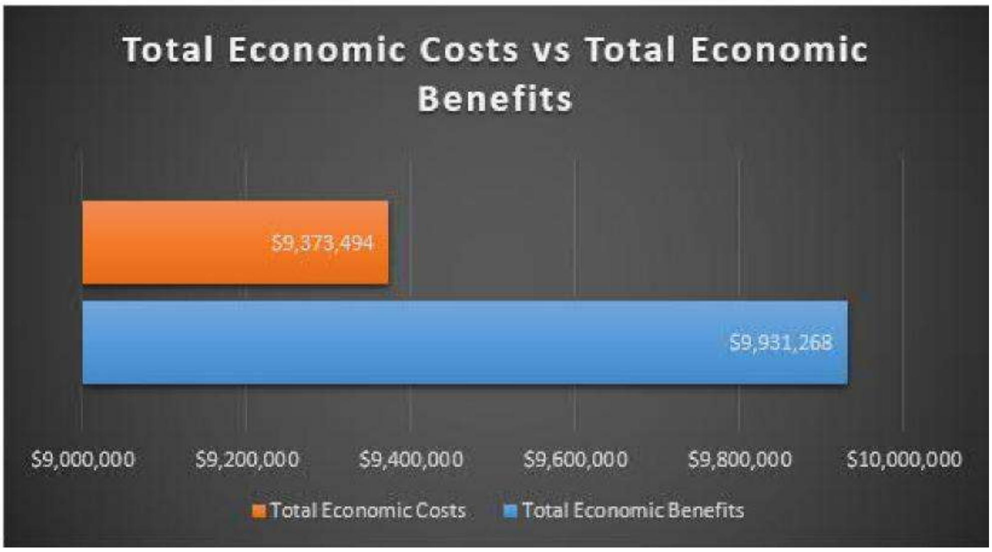

Figure 3:'Summary sheet' tab within the Benefit-Cost Analysis tool.