Economic appraisals of road clearways

Julieta Legaspi[1], Natalie Liew[1], Baojin Wang[1]

[1]Transport for NSW

Email for correspondence: Julieta.legaspi@transport.nsw.gov

Abstract

This paper presents a framework and a model for strategic assessment and economic appraisal of Clearways. Clearways aims to improve travel time on major roads during the morning and afternoon peak as well as relieving road traffic congestion by prohibiting kerbside stopping on large sections of main roads for vehicles to provide additional capacity for moving traffic operating at capacity, thereby reducing congestion.

The strategic assessment is a decision-support tool that checks whether a specific clearway proposal aligns with transport objectives, policies and strategic plans and other important factors. The tool uses both quantitative and qualitative information to provide a first pass assessment of clearway projects to come up with a list of possible projects that can be prioritised and can go through the second stage assessment that includes full economic appraisal.

The paper presents a methodology for cost benefit analysis of clearway projects either for the extension of current operating clearway times or the expansion of the clearway network to include new road sections. The benefit estimation considers traffic volume distribution by time of day, direction and other road characteristics such as road capacity. The cost benefit analysis (CBA) model utilises localised traffic data to provide key economic evaluation results such as the BCR and NPV. The CBA model for clearways provides the capability to estimate benefits such as travel time savings based on speed flow relationship, vehicle operating cost savings, as well as other benefits such as environment and accident savings.

Key words:
Road clearways, framework CBA model, prioritisation approach

1. Introduction

One of the means to address road congestion on the road network is through the use of clearways. A clearway is a section of road where stopping or parking is prohibited. The only vehicles excluded from these restrictions are public buses and taxis which are permitted to stop when dropping off or collecting passengers.

Clearways help reduce congestion by allowing motorists to use all traffic lanes which provides greater road capacity, improved traffic flow on congested corridors and on the road network, reliable travel times for buses, reliable travel times for freight vehicles and a safer road network. Clearways can be 24 hour, peak times only, at weekdays, weekends or anything in between. A weekday morning and evening peak (4 hour peak period operations) has traditionally been adopted for implementation.

This paper presents a methodology for cost benefit analysis of clearways and develops a model to estimate the associated cost and benefits demonstrated through a case study.

2. Role of Economic Appraisal

Economic appraisal plays an important role in investment decision making by ensuring the alignment of program objectives with strategic plans to ensure the best transport investment outcomes. Through cost-benefit analysis, economic appraisal assists informed investment decisions to ensure value for money, ranking and prioritisation of investments and optimal resource allocation.

An economic appraisal compares and evaluates the benefits and costs with and without the investment option. The identification and measurement of benefits are not only financial but economic in the sense that it includes those benefits that accrue to the community. The results of an economic appraisal include the Net Present Value (NPV) and Benefit Cost Ratio (BCR) which are key indicators used to determine whether the project is economically viable.

This paper presents a framework for conducting economic appraisal of Clearways and the methodology, including the identification and valuation of costs and benefits of implementing clearways which is demonstrated through a case study. The economic appraisal results for the case study are presented which include project costs, road user benefits and externality impacts.

3. Methodology

3.1. Strategic Merit Assessment

There are major roads which currently have a peak period clearway in place, which could be improved by extending the weekday hours of operation to all day (such as 6am to 7pm). The need to introduce weekend clearways on major roads is also evident, with considerable traffic volumes experienced across Saturday morning, midday and afternoon. In addition there are hundreds of possible clearway sections that can be introduced.

To assess these possible extensions and introductions of new clearways, a strategic merit assessment can be used to identify hot spots based on traffic data (traffic volumes and travel speeds) for the morning peak, afternoon peak and on weekends. Assessment of these corridors can be done using additional criteria such as bus and freight priority, travel consistency along a corridor and alternative parking options, before determining where clearway projects will be further developed. This can also point to the areas where community consultation needs to be undertaken.

The strategic merit assessment can provide a first pass assessment to come up with a list of priority projects that can be prioritised and can go through the second stage assessment which is full economic appraisal. This assessment is based on broad strategic decision criteria developed with key stakeholders. A set of these criteria are presented below as examples which are grouped into the following categories:

1 STRATEGIC: proposed clearway is part of a constrained strategic corridor, a strategic bus and/or freight transport corridor. The relative importance is also captured to reflect the priority of a route in meeting people and goods movement. The proposed clearway supports integration of intersection, multi access facility, and major multi access facility.
2 ELIGIBILITY: proposed clearway is on road with high traffic flow (exceeds 800 vehicles/hr/lane) and is experiencing low speeds (<30km/hr during peak) based on current and projected traffic.
3 CONNECTIVITY: connects to people and communities, i.e. demand generators and the presence of alternative business public parking close to local businesses.
4 SUSTAINABLE TRANSPORT: transport can support the projected traffic growth in the link and surrounding routes / network.

5 CONFLICTING ROAD MANAGEMENT INITIATIVE: Are there current and other planned works along the route that would lead to meeting the same objectives and outcomes as a clearway restriction?
6 ROAD CONSISTENCY, ENVIRONMENT AND ROAD USER EXPERIENCE: the proposed clearway contributes to improvement in road travel consistency, reduction in local traffic congestion, noise abatement, improvement in landscape, townscape, and overall road user experience.
7 SAFETY CONSIDERATION: the proposed clearway is located in a blackspot or high accident risk area or in the vicinity that may be reduced by clearway restrictions such as a history of rear end and side swipe crashes. Does the route experience a high level of unplanned incidences? Also include consideration of number and severity of incidents.
8 RESOURCE OPTIONS whether there are funding sources available, i.e. transport internal budget, sharing with local resources, Federal grants.
9 READYNESS / DELIVERIBILITY: technical consideration of ease of implementation. Whether the project can be completed in 12 months, within 2 years, 3 years +
10 COSTS: whether this is required and how it is to be included, i.e. whether to give high score to smaller projects.

3.2 Economic Framework

For undertaking the economic appraisal, an economic framework is suggested which consists of 5 components:

1. Road capacity modelling
2. Speed flow relationship modelling,
3. Benefits estimation,
4. Cost-benefit analysis and
5. Optimal clearway operations.

This framework is presented in Figure 1.

3.3 Model data requirement

The data required to undertake the full economic appraisal includes:

Project information

- Clearway location
- Proposed clearway operating period e.g. AM and PM peak, weekdays, weekends, all day, 24 hours
- Direction of operation e.g. Inbound/outbound
- Road safety accident data
- Number of parking spaces impacted; whether there are alternative business parking spaces.
- Retail activity along proposed clearway and adjacent land use e.g. shopping strip, commercial hub, residential areas

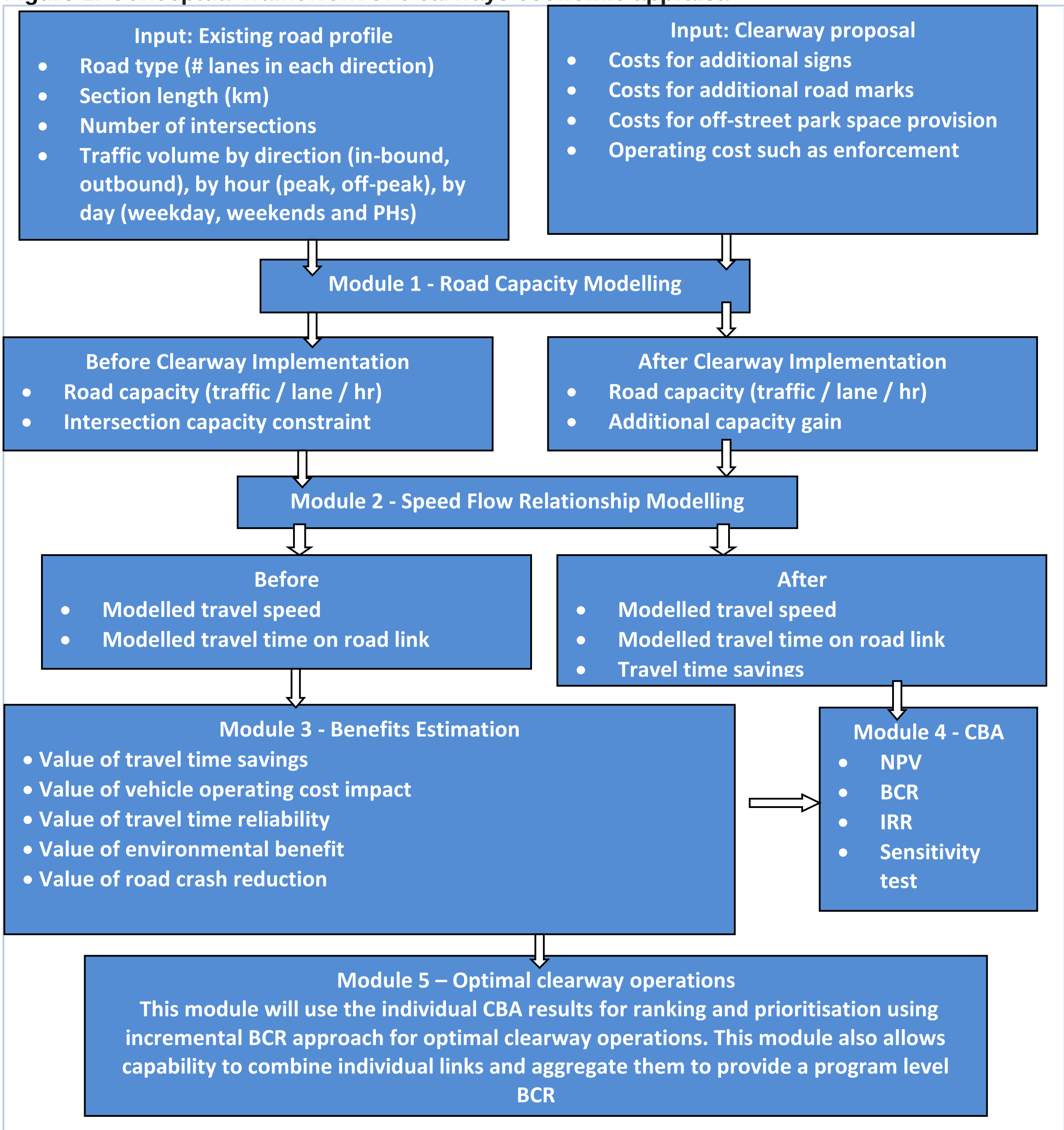
Costing

- Capital costs of clearways such as signs, projects costs
- Associated operating costs such as lane markings, enforcement monitoring
- Other infrastructure costs such as those involved in sourcing alternative car parking e.g. construction of dedicated off-street parking

Traffic data

- Hourly traffic volume by each direction, weekday and weekend
- Road capacity and link type e.g. mid-block, intersection
- Average travel time/speed along section of proposed clearway

Figure 1: Conceptual framework of clearways economic appraisal



3.4. Cost Benefit Analysis (CBA)

Cost benefit analyses were conducted for clearway implementation and presented as a case study. The routes that form part of this case study were chosen due to data availability, criteria for the proposed clearway were met and the road represents different traffic travel profile (commuter, freight, and bus). The CBA for each of these clearways are discussed in the following sections. Essentially, the basic steps are:

- Development of detailed methodology for benefit estimation considering traffic volume distribution by time of day and direction and other road characteristics such as road capacity and speed flow relationships.
- Analysis on intersections and links for economic evaluation of clearway proposals which could be useful for prioritisation of individual projects as well as capability to combine individual links and aggregate them to provide a program level BCR.
- Development of a cost benefit analysis (CBA) model to calculate the BCR and NPV.

The CBA model for clearways estimates the economic benefits such as travel time savings based on speed flow relationships, vehicle operating cost savings, environment savings as well as other benefits such as accident cost savings. The model relies on estimating speed flow relationships from key data such as traffic volume.

The speed-flow model can accommodate different scenarios:

- Changing the clearway periods, e.g., peak hours only to 12 hour or 24 hours clearway
- Changing clearway direction, e.g., Eastbound to Westbound or in both Eastbound and Westbound
- Changing clearways from weekdays only to full week including weekends

- Link-based analysis for economic evaluation of individual clearway proposals in order for prioritisation as well as capability to combine individual links and aggregate them to provide a program level BCR.

The key inputs to the clearway CBA model include:

- Average hourly traffic volume
- Current clearway operation on weekday and weekend (operating time)
- Proposed clearway operation (i.e. clearway operation on weekends, extension of clearway times)
- Length of road sections for additional clearways
- Road capacity
- Number of lanes
- Capital and operating costs
- Number of crashes

Costs were then annualised using an appropriate expansion factor (TfNSW 2013) and traffic growth of 1.4% is applied each year.

4. Case study

The aim of the case study is to demonstrate how the proposed cost benefit analysis methodology can be used for a clearway project appraisal. Clearways are typically implemented in strategic corridors with high traffic volumes, low speeds and alternative parking close to businesses. The case study presents an arterial road that is mostly 3 lanes in both eastbound and westbound directions. Only two traffic lanes are left in some road sections where the kerbside lane is used for parking during the inter peak period on weekdays and on weekends.

4.1 Base Case and Project Option

The Base Case, Option, the base year and the evaluation period of the cost benefit analysis is defined as follows:

Base Case – Current clearway operating conditions

There are existing clearways operating in peak periods on weekdays from 6-10am and 3-7pm in both eastbound and westbound directions of traffic. Traffic volume data suggests that this arterial road is busy carrying a high volume of traffic averaging over 1,700 vehicles per hour on the weekends, with more traffic heading eastbound.

Project case – Extension of clearway operation to weekends

It is proposed that clearway conditions be implemented during the weekend from 8am to 8pm, in addition to the current clearway operations during the peak period on weekdays.

This translates to an incremental 7km of free road space due to the proposed Clearways in both directions.

Base Year - The base year of the CBA is financial year 2013/14. All costs and benefits will be discounted to the base year for estimating the Net Present Value (NPV) and Benefit Cost Ratio (BCR).

Evaluation Period - The evaluation period is 10 years after the capital expenditures.[1]

4.2 Costs

The following are the estimated costs that will be incurred in the extension of Clearways. The estimated capital costs are relatively small.

4.2.1 Capital, operating and maintenance costs

- Signage – New clearway signage and installation on both sides of the road is required due to the change in clearway times. It is assumed a unit cost of $240/sign including installation.
- New road markings – New road markings (materials and labour) for clearways such as broken yellow lines on the kerb side lane. The cost of road markings is estimated as $2,178/lane-km based on research from the US using thermoplastic paint.[2]
- Road marking operating and maintenance cost assumed to be $500/lane-km p.a.
- Other infrastructure costs – Clearways are implemented in areas where alternative parking can be found and is available. Other infrastructure costs can include costs to identify alternative parking.

These costs are summarised in Table 1.

Table 1: Project costs- undiscounted $13/14 values, $m

	Annual cost ($m)
Capital cost	
Signage	$0.083
Road markings	$0.077
Other infrastructure costs	$3.000
Operating & maintenance cost	
Road markings	$0.017
Total	$3.176

4.3 Quantifiable Benefits

4.3.1 Estimating travel time saving benefit

Estimating speed improvement due to clearway

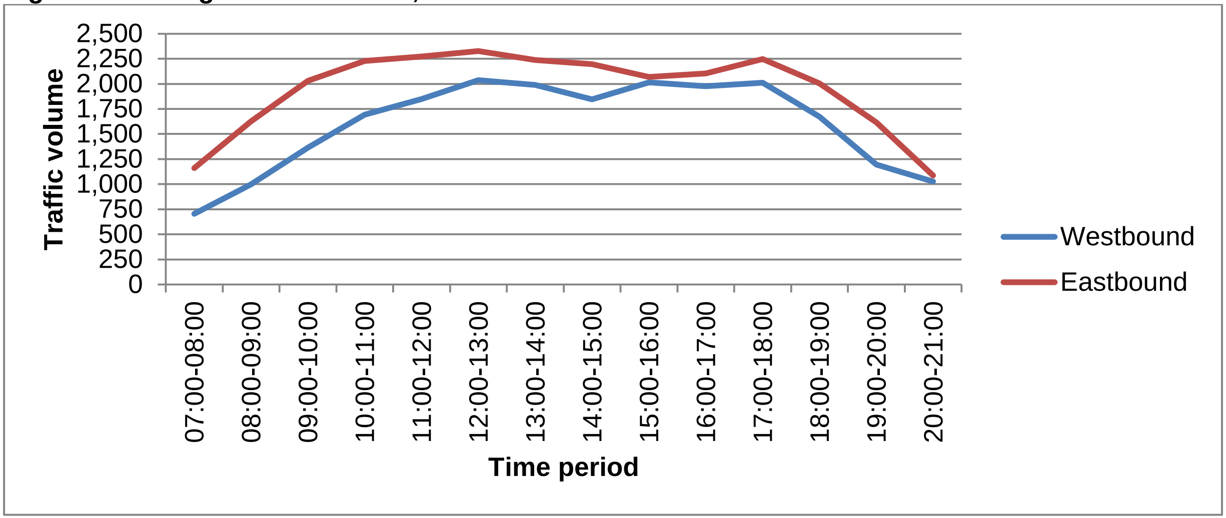
One of the main components of the CBA model is modelling road capacity and the speed flow relationship. Traffic volume data for each hour is obtained from traffic survey counts on Saturday and Sunday for both directions of traffic flow. Figure 2 illustrates the average weekend traffic volume along the impacted section of the arterial road from the survey

[1] Policy changes are typically evaluated over 10 years and is appropriate given the type of capital costs involved so that benefits are not overstated.
[2] Estimated cost based from research by Miller (1992).

counts. Traffic volume on weekends tends to be distributed throughout the middle of the day. This is different to weekdays where traffic volume is concentrated on the peak periods.

Using the traffic volume for each hour, the volume capacity ratio can be calculated. The travel time and speed (being the inverse of each other) for each hour is estimated using the Austroads speed flow relationship which is a function of free flow speed, delay parameters (such as ramps and traffic signals) and volume capacity ratio (Austroads 2011). The travel time and speed for each hour is modelled for the Base Case and Option (i.e. with clearway, by changing the time of day and including weekend according to the Clearway proposal). The difference between the Project Case and Base Case is the improvement in speed and decrease in time resulting from the Clearway.

Figure 2: Average traffic volume, weekends



Travel time costs

Using the speed flow relationship, the travel time along the kerbside lanes and other lanes for each hour of the day is modelled. The kerbside lane typically holds less capacity. The average speed travelled on the road for each hour was calculated. The travel time cost is estimated by multiplying the travel time (function of distance of additional Clearways and modelled average speed) by the value of travel time and the traffic volume separated out for cars, trucks and buses. The value of travel time for cars includes the travel time cost for private and business car trips (87% private car trips and 13% business trips) (TfNSW 2016).

Similarly, bus travel time cost includes passenger private trips (97.6%) and business trips (2.4%) as well as bus driver value of travel time. The average number of passengers per bus was taken into account in the calculation of travel time benefits for each bus passenger. The annual bus patronage, the bus routes identified in the road section and the number of bus trips on these routes along the arterial road were used to calculate the average bus passengers per trip of around 34.

The traffic volume counts was not able to separately identify the types of trucks, thus the travel time value for the representative ‘heavy 3 axle truck’ was used. The total travel time cost is then aggregated for each hour and for both directions.

Travel time savings

The extension of clearway operating times provides greater road capacity as it frees up the kerbside lane to be used for through traffic which was previously used for parking. During periods of high traffic volumes in the peak period and on weekends on the arterial road, a small increase in capacity can lead to large travel cost savings. As a result of increased capacity, average speeds have increased which provides travel time savings. Based on traffic modelling results, it is estimated that the extension of clearway operating times to weekends will provide an improvement in average speeds of approximately 6km/hr. Travel time savings represent the majority of benefits.

4.3.2 Vehicle Operating Costs Savings

The Urban Stop-Start Model was used to estimate the vehicle operating cost with speeds below 60km/hr. The vehicle operating cost values used in the Urban Stop-Start Model were weighted using the traffic composition of cars, trucks and buses. Under urban conditions, vehicle operating costs generally decrease when speed increases until a certain speed threshold is reached, then vehicle operating costs start to increase again.[3]

VOC savings are realised as speeds increase along the section of road during periods of Clearway operation as there is greater capacity. The urban stop-start model indicates that increases in speed lead to a decrease in vehicle operating costs if the prevailing travel speed is less than 60 km/h.

4.3.3 Safety

There are different types of countermeasure treatments to reduce accidents such as clearways, new traffic signals, and pedestrian refuge. The effectiveness of clearways in reducing accident types (in terms of percentage reduction) is summarised in Table 2.

The extension of clearway operation is likely to provide a more predictable driving environment, eliminating the risk of crashes involved in rear end and lane change crashes as a result of parked cars. The types of crashes which are expected to be reduced as a result of clearway implementation identified in the Road Safety BCR Model[4] are two vehicle crashes resulting from U-turn, rear end, manoeuvring/lane change, hitting a parked vehicle and single vehicle crashes involving hitting a pedestrian. Data on the number and type of crashes along the road section is provided by the RMS CrashLink database.

The average annual number of crashes from 2008-2012 on the road section proposed for clearway changes were around 185 crashes, with a higher average number of crashes occurring on weekends compared to weekdays. The majority of crashes are rear end crashes, which might be driven by drivers unexpectedly stopping upon realisation of parked cars in the kerb side lane, intersection approaches and lane changes as drivers merge from the kerb side lane due to parked cars.

To estimate the accident cost savings, the crash reduction rates as a result of clearways treatment is applied to the average annual number of crashes. However, the reduction in crashes attributable to the project needs not only to consider the reduction rates but also the proportion of traffic operating during the clearway period on weekends (approximately 60% of daily traffic is in clearway times). Using the reduction rates and accounting for the proportion of crashes on weekends, it is estimated that the project can result in a reduction of about 13 crashes per year, amounting to an annual accident cost saving of $0.64m. This estimate uses the crash reduction rates for some crash types that are considered avoidable due to clearways based on the Road Safety BCR Model 2006.

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[3] TfNSW (2013) Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives, Appendix 4. Value of Travel Time is $14.51 for private trip and $46.45 for business trip in 2012/13 dollars.

[4] Road Safety BCR Model 2006 Version was used. This model was developed by Centre for Road Safety NSW. A new 2016 version is available but the clearway measure reduction was not estimated in this version thus the use of the 2006 version.

Table 2: Crash reduction

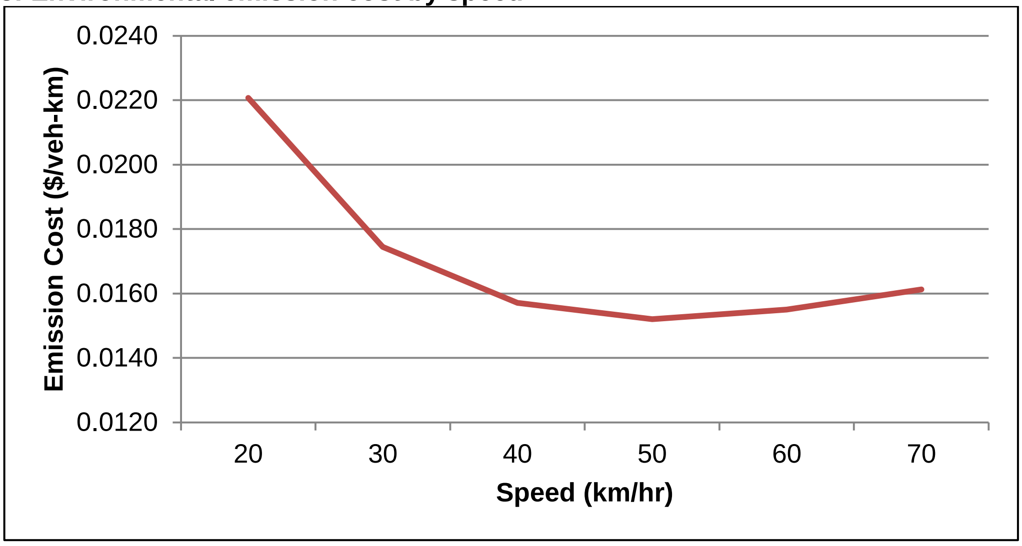
Countermeasure	Crash type	Reduction	Crash cost ($/crash) TfNSW (2013)
Clearways / parking restriction	**Two vehicle crash**		
	U-turn	20%	$55,600
	Rear end	20%	$38,000
	Manoeuvring/lane change	20%	$49,200
	Hit parked vehicle	50%	$60,600
	Single vehicle crash		
	Hit pedestrian	30%	$193,600

4.3.4 Improvement in Environment

There is a reduction in vehicle emissions as a result of increased speeds. Environmental costs are calculated based on emissions generated from fuel burned represented as a carbon dioxide equivalent. Emissions decrease as speed increases however then start to increase again after a certain threshold. However in the urban environment with speeds typically bounded by 60km/hr on this section of arterial road, increases in speed lead to less fuel consumption thereby generating less emissions, providing environmental cost savings.

The environmental cost is estimated by using the relationship between speed, fuel consumption and greenhouse emissions. Environmental emissions such as greenhouse gases and air pollution generated from fuel burned are expressed as a carbon dioxide equivalent (CO_2-e). Fuel consumption of vehicles by speed (weighted by vehicle types) was estimated[5] and multiplied by the CO_2-e conversion factor (to convert fuel burned into CO_2-e emissions)[6] and the carbon price[7] to obtain the emission cost by speed. Figure 3 shows the estimated relationship between speed and environmental costs. It is noted that there could be increases in noise due to loss of parked cars acting as a buffer which could offset the environmental benefit however this is likely to be insignificant.

Figure 3: Environmental emission cost by speed



[5] TfNSW VEHOP model is used to estimate fuel consumption output by speed for each vehicle type (car, LCV, rigid truck, articulated truck). Vehicle type proportions were then used to weight the fuel consumption by speed.

[6] 2.3kg of CO_2-e produced from 1L of fuel burned

[7] TfNSW (2013) Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives, Appendix 4, Table 54.

4.3.5 Summary of Clearway Benefits

Table 3 shows the benefits of clearways extension in the arterial road during weekends.

Table 3: Summary of Clearway benefits, undiscounted $13/14 values, $m

Benefit ($m)	Year 1	Year 2	Year 3	Total Years 4-10	Grand Total
Travel time savings	3.49	3.53	3.57	26.15	36.73
VOC savings	0.17	0.17	0.18	1.28	1.80
Accident cost savings	0.64	0.64	0.64	4.51	6.44
Environmental cost savings	0.01	0.01	0.01	0.09	0.12
Total	4.32	4.36	4.40	32.03	45.10

4.3.6 Summary of CBA Results

Table 4 presents the results of the CBA conducted to assess the extension of clearways in the arterial road in the case study. At the 7% discount rate the BCR is 9.6. The proposed clearway projects are expected to generate positive gains as the BCR is greater than 1.

Table 4 CBA Summary Results

Costs and benefits	Values
PV Cost ($m)	3.28
PV Benefit ($m)	31.48
NPV ($m)	28.20
BCR	**9.6**

4.4 Unquantifiable costs and benefits

There are costs and benefits which are possible but have not been evidenced and quantified. These are:

Other Possible Costs

- Parking spill over to surrounding off streets.
- Enforcement costs. Incremental towing contract costs are likely to be insignificant. During weekends ‘on call’ towing contracts are likely to be used in which a set fee is paid for the provision of Clearway tow away services when reported with a response time of 40 minutes (outside weekday clearway operating times).

Other Possible Benefits

- The use of Clearways provides a means to improve road capacity by utilising existing road infrastructure which can be relatively easy to implement without the need to build new infrastructure which can be more costly.
- Improved vehicle access from local side streets to arterial roads.
- Reduction in heavy vehicles using local streets. Without clearway, heavy vehicles use local streets to avoid traffic congestion on main arterials.
- Removal of kerb side parking improved sight distances for pedestrians which can potentially reduce the number of crashes involving pedestrians.
- Reliability savings. With the increase in road capacity resulting from extending Clearway operation, it is expected that reliability savings can be generated.

5. Conclusions

The CBA indicates that the proposal to extend clearway operations in the case study would generate a positive NPV of $28.2 million and a BCR of 9.6. The CBA is based on the following principles:

- Traffic modelling conducted on an hourly basis which considers traffic volume, road capacity and the speed flow relationship in the Base Case and Clearway Option. The difference between the Base Case and Option is the impact of the Clearway proposal.
- Capital costs associated with clearways which typically include costs for signs and road markings are relatively small.
- The main benefit is travel time savings as a result of increased road capacity during clearway operations as parked cars are removed. Travel time benefits for bus passengers are also captured. Other benefits include VOC savings and environmental cost savings due to increases in speed and reduction in crashes as crash types such as rear end, hit parked car, U-turn and lane manoeuvring crashes can be avoided.
- Future work may involve conducting a post completion report and benefit realisation studies on potential Clearway projects as it would be useful to compare estimated benefits to realised outcomes and any other useful lessons learnt.

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References:

Austroads (2011) Speed flow relationships: Implications of project appraisal, Austroads AP-R393-11.

Bureau of Transport Statistics (2012), 2010/11Household Travel Survey 2012 Release.

Miller, T.R (1992) Benefit Cost Analysis of Lane Marking, Transportation Research Record 1334, TRB Washington D.C., pp.38-45.

Transport for NSW (2013) Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives, TfNSW.

Transport for NSW (2013) Sydney Clearways Strategy, TfNSW.

Transport for NSW (2016) Household Travel Survey data, website: http://www.bts.nsw.gov.au/, accessed on October 4, 2016