Roads and Traffic Authority of NSW and the Department of Environment and Climate Change

Evaluation of the costs and benefits to the community of financial investment in cycling programs and projects in New South Wales

Final Report

14 April 2009
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This report has been prepared by PricewaterhouseCoopers (PwC) at the request of the Roads and Traffic Authority of NSW (RTA) and of the Department of Environment and Climate Change (DECC), to evaluate the costs and benefits to the community of financial investment in cycling programs and projects in NSW.

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Summary

As well as providing a means of transport, cycling offers tangible benefits for those who participate and for society as a whole. These include contributing to individuals’ health, improving the environment, mitigating the problems of congestion, providing independence to children and other disadvantaged groups, improving the quality of life for communities and, in many areas, supporting tourism.

The NSW Government is aware of these benefits and bicycle networks have expanded significantly over the last decade. On 30 August 2008, the NSW Minister for Roads and the NSW Minister for Climate Change and the Environment announced the preparation of a new plan for cycling in NSW. The new NSW BikePlan will aim to encourage more people across the state to use bicycles as a clean and healthy transport choice, particularly for short trips.

The new NSW BikePlan will reinforce the importance of having a truly connected network of cycle paths. The new NSW BikePlan will include the development of the Sydney Strategic Cycle Network, a high-standard, off-road continuous cycle routes that will link important destinations together such as employment centres, education centres, retail areas, and recreational venues. These locations have all seen considerable jobs growth, increased services (major medical, retail and entertainment activities), and residential development.

Benefits of cycling

There are a wide range of benefits associated with the promotion of cycling and the improvement of cycling facilities. For individual cyclists, cycling provides benefits in terms of improved health, reduced transport expenses and lifestyle enhancements. These benefits also accrue to pedestrians who walk along cycle ways.

These benefits accrue to:

- existing cyclists and pedestrians whose current levels of cycling or walking can increase if they have access to more attractive facilities and/or existing facilities are extended to accommodate more, or better cycling and walking routes; and
- potential cyclists and pedestrians, for whom the probability of cycling or walking is increased due to more attractive facilities and/or the location of new facilities in their close proximity or proximity around facilities to which they are likely to attend.

Where cycling or walking along cycle ways generates reduced car use, benefits also accrue to the wider community. Wider community benefits relate to any reduction in congestion and pollution, improved urban liveability, and any financial savings that arise from the deferral of other transport investment or the protection of access routes that might be required by Governments in the future.
These changes generate a series of financial, social, and environmental impacts that can be valued and compared to the cost of cycle way infrastructure investment.

**The net benefit of expansions in cycling infrastructure**

This study assesses the net benefits of investing in 9 of the 12 major missing links of the Sydney Metropolitan Strategic Cycle Network for which demand forecasts are available.

The quantifiable benefits of cycling or walking along cycle ways are largely a function of the amount of cycling or walking. They will invariably depend on finer details such as the location, purpose, person cycling or walking, and characteristics of the facility being used. The overarching issue is reliably determining an economic value for a facility for which there is no market value and little data for its use.

A series of expected impacts of the proposed missing link cycle ways have been identified and subject to Cost Benefit Analysis (CBA). The information and assumptions used in this analysis are based on data provided by the RTA and an extensive literature review on cycling benefits and methodologies for estimating the value of cycling infrastructure.

Using the most conservative assumptions in all cases, the estimated net benefits of cycling were found to be 48.22 cents per bicycle kilometre.

<table>
<thead>
<tr>
<th></th>
<th>(2008 ¢ / bicycle km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decongestion benefit</td>
<td>24.28</td>
</tr>
<tr>
<td>Savings in user cost</td>
<td>16.39</td>
</tr>
<tr>
<td>Parking cost savings</td>
<td>1.00</td>
</tr>
<tr>
<td>Travel time costs</td>
<td>0.00</td>
</tr>
<tr>
<td>Bicycle crash cost</td>
<td>-2.03</td>
</tr>
<tr>
<td>Health benefits</td>
<td>1.42</td>
</tr>
<tr>
<td>Air pollution reduction</td>
<td>1.73</td>
</tr>
<tr>
<td>Noise Reduction</td>
<td>0.85</td>
</tr>
<tr>
<td>Infrastructure provision</td>
<td>3.91</td>
</tr>
<tr>
<td>Greenhouse Gas Reduction</td>
<td>0.66</td>
</tr>
<tr>
<td><strong>TOTAL Net Benefit</strong></td>
<td><strong>48.22</strong></td>
</tr>
</tbody>
</table>

Combined with the demand forecasts and expected track configurations, the results indicate the missing link projects are economically viable, producing a net present value of incremental benefits of $29.84 million and benefit cost ratio (BCR) of 1.3. This is based on the results of a discounted cash flow model over a 20 year evaluation period following the construction of the new cycle ways, with future cost and benefit streams discounted using a 7% discount rate (real). Arguably, a 4% discount rate could be used in recognition of the social capital value of cycle ways described elsewhere in this report, as is conventionally used internationally for projects with social capital importance and intergenerational values. Using a 4% discount rate provides a BCR of 1.8, whilst still using conservative estimates for the benefits streams.
Some of the key conservative assumptions used to estimate the benefit streams include the following:

- Forecast utilisation includes demand from the following groups:
  - New cyclists for trips that are diverted from private car trip.
  - Demand from new cyclists for trips that are diverted from public transport and walking trips, derived from the forecast increase in diverted car trips, pro-rated in accordance with the Sydney transport mode share for public transport and walking trips.¹
  - Induced cycling journeys that would not have taken place had the infrastructure not been created. This includes people that take up cycling for recreational and exercise purposes, in effect creating new cycling journeys. Because these people don’t represent a mode shift, no benefits can be allocated that relate to avoided costs for car and public transport travel. However, these people do enjoy the health benefits. Insufficient data exists to accurately gauge this demand. A conservative assumption has been made that this will lead to a 5% increase in total demand and applies only to the calculation of health benefits.
  - Induced pedestrian journeys that would not have taken place had the infrastructure not been created. As with new cyclists above, this includes people that take up walking on the new cycle ways for recreational and exercise purposes rather than being inactive. A conservative assumption has been made that this will lead to a 2% increase in total demand and applies only to the calculation of health benefits.

- Demand from current cyclists is not included in forecast utilisation, although it is expected that existing cyclists will also use the new cycle ways. Demand from this subgroup is excluded from the quantitative analysis given that existing cyclists already receive health benefits associated with cycling and their expected displacement of motorised transport trips is likely to be limited. This group are expected to incur only qualitative benefits associated with improved cycling enjoyment and improved utilitarian outcomes.

- Demand from displaced pedestrian trips for cycling trips is also excluded from the demand forecasts, with no benefits assigned to this group.

- For demand associated with displaced car trips, a conservative car occupancy rate of one is assumed. Although the RTA specifies an

¹ Most recently available transport mode share data from the Transport Data Centre (2002) for Sydney indicates that car travel accounts for 69.7% of all journeys in Sydney. This analysis assumes that demand for cycling generated by the missing links projects accounts for 69.7% of total demand and demand from displaced public transport and walking trips is 30.3% of demand.
average occupancy of 1.12 during peak and 1.97 outside peak and business hours, the demand forecasts for the proposed cycle ways are based on trip numbers, not cyclist numbers and differentiating the demand pool by commuter and non commuter trips introduced unjustified degrees of errors in the results.

- Sensitivity analysis has been undertaken to assess the robustness of the CBA results to changes in the investment cost, and changes in the uptake and value of cycling benefits.

Sensitivity tests demonstrate that:

- the projects remain economically viable using a higher (10%) discount rate, indicating economic viability at full risk adjusted capital costs;
- the projects remain economically viable using a lower demand scenario, indicating the viability of the project is not sensitive to unexpected swings in demand and take-up rates;
- results are sensitive to decongestion benefits – i.e. if you assume suppressed demand results in no decongestion benefits or changes to the vehicle usage of other motorists, the projects lose economic viability; and
- adopting the World Health Organisation methodology to estimate health benefits provides a very positive BCR of 3.1, which would remain positive even if no decongestion benefits were realised (BCR would be 2.0).

The ‘social capital’ value of the missing link cycle ways

Alongside economic efficiency considerations, transport options are increasingly being assessed in terms of their importance to generating and sustaining ‘social capital’.

Social capital refers to the connections within and between people’s social networks. Social capital essentially enables individuals to function cooperatively for mutual benefit. While it embodies many concepts related to equity and fairness, it is much broader than this and is linked to:

- positive mental and physical health outcomes;
- equality and welfare;
- better educational outcomes
- decreasing crime and violence; and
- improving governmental responsiveness and efficiency.

The activity of cycling and the presence or absence of cycling infrastructure has its own particular impact on social capital including:

- **Providing mobility to all** – In terms of both running and maintenance costs and maintenance costs, cycling is one of the lowest cost transport options available, meaning that individuals from more socio economic groups, and more locations, can be upwardly mobile. By providing relatively equal access to all, bicycles reduce social
exclusion and allow access to employment, education, housing and other social and community services.

- **Empowering children and aged persons** - bicycles afford children and aged people a mode of transport and a sense of independence. Independent mobility has been found to greatly improve the socialisation of children, and both children and their families who live in neighbourhoods not dominated by traffic, with more opportunities for cycling, and access to parks and play spaces, having wider sets of friends.

- **Improving access** – Bicycle travel allows users to access locations which are not serviced by public transport, or even not accessible by road. It also enables people to travel at their convenience, unrestricted by routes or timetables. Further, when linked with other public transport modes cycling can open up cities to those without access to a car.

- **Supporting community development** – People who cycle have been found to be more likely to access local goods and services, and support small businesses in their area. This increases the interaction between members of the same community and aids in the building of cohesive local networks.

- **Sport and recreation** – Bicycle users are able to engage in sport and recreational activity whilst fulfilling alternative trip purposes, with considerable health benefits. Bicycles also enable user to access community sporting facilities and sporting fields which are key hubs for social interaction between community members. Social and competitive team cycling expeditions are also contributors to the socialisation, health and wellbeing of participants.

- **Facilitating engagement with others and engagement with the community** – Cyclists are able to communicate with others whilst travelling, being able to sense the actions of all others around them and remain immersed in the streetscape environment. This kind of travel – where individuals are not shielded form their surroundings - imparts a greater sense of connectedness with the community for both the traveller and other people.

- **Opening up public spaces** – Because bicycle travel is possible without the need for socially disruptive infrastructure, such as roads, railway lines and bus terminals, cycling has negligible impacts on the social environment. In effect this can open up public spaces for more members of the community to enjoy, an important contributor to social capital.

- **Potential to improve land use decisions** – incorporating cycle ways into the built environment is likely to have a positive influence on the ability to access jobs, entertainment, schools, and other facilities by bike, improving the uptake and frequency of cycling trips and enhancing the social capital value of those trips.

- **This report compares the social capital value of cycling to other methods for achieving trip purpose. Each mode choice is assessed in terms of the extent to which it has a positive effect on social capital (i.e. a high, moderate, low or nil effect).**
Both cycling and walking were shown to generate moderate to high contributions to social capital compared to private car and public transport use. This is because they allow for more interactions and greater connection with the community. Their high scores also reflect their strong linkages with sport, leisure and recreational activities, contributing to greater wellbeing of community members. They are also the most easily accessible forms of transport, allowing children and economically disadvantaged groups equal mobility.

Private vehicles afford owners a high level of mobility and feelings of safety, however overall, the typology used suggests as a mode of transport they contribute little to the development of social capital. The main reasons for this include:

- inability to connect socially with outsiders whilst travelling;
- dominating nature of motor vehicles on community roads;
- higher risks and severity of accidents; and
- the exclusion of children and less advantaged group from access.

The social capital analysis in this report supports the view that the cycling mode provides almost double the social capital value of private vehicles as a transport choice for community members.

The social capital value of each individual cycle way has also been assessed, which indicates that all proposed cycle ways have a moderate or high number of social capital attributes.
1 Background

Why cycle ways matter

Cycling contributes to a wide range of transport, social, and environmental policy objectives. As highlighted in the Australian National Cycling Strategy 2005-2010, these include:

- providing safe, affordable and enjoyable movement of people and goods;
- reducing the environmental and health impacts of transport, for instance by reducing motor vehicle gas emissions (including greenhouse gas) and noise emissions;
- increasing the level of physical activity;
- reducing the levels of traffic congestion, which is increasing travel times and industry costs;
- reducing the dependence on the private motor vehicle;
- increasing the use of ‘active transport’ (walking, cycling and public transport); and
- providing a transport system that offers attractive choices for travel other than by private vehicle.

Cycling is an essential element of a sustainable transport system and creates more liveable cities and improves access and sociability within communities. It provides a low-cost, healthy form of transport, particularly for young people without a driving license or without access to a car. It also complements the public transport system, providing multi-modal journey options for longer trips and therefore increasing public transport catchments.

Given that cyclists can easily cover distances of five kilometres or more, the bicycle also offers an equitable and affordable method of travel that can widely expand the range of employment, education, goods and other services accessible from home, as well as social supports, such as friends, meeting places and clubs. With 52% of car trips in Sydney being less than 5 km long, there is considerable scope to increase the use of cycling to meet people’s transport needs.

As well as providing a means of transport, cycling offers tangible benefits for those who participate, as well as wider benefits for society as a whole. These include contributing to individuals’ health, improving the environment, mitigating the problems of congestion, providing independence to children and other disadvantaged groups, improving the quality of life for communities and, in many areas, supporting tourism.

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The NSW Government is aware of these benefits and bicycle networks have expanded significantly over the last decade. The quality, safety and attractiveness of cycling infrastructure have been improved as a result of better design guidelines, and the effectiveness of urban planning.

Even so, one of the major additional barriers to increased cycling trips lies in the perceptions of the general public. Cycling in an urban environment may be seen as dangerous, especially by women, a group under-represented among cyclists.

Public investment in cycling infrastructure

In 1999 the NSW Government released ‘Action for Bikes’: BikePlan 2010, including a commitment to spend $251 million over 10 years to deliver an average 200km of cycle ways per year. At the end of 2008, the NSW Government had actually provided more than $291 million towards cycling projects and programs since BikePlan 2010 was released, and an average 233 km of cycling facilities have been delivered each year since 1999. There are now more than 4,100 kilometres of on and off-road cycleway in NSW.

On 30 August 2008, the NSW Minister for Roads and the NSW Minister for Climate Change and the Environment announced the preparation, under the leadership of the Premier’s Council for Active Living (PCAL), of a new plan for cycling in NSW. The new NSW BikePlan will aim to encourage more people across the state to use bicycles as a clean and healthy transport choice, particularly for short trips.

The new NSW BikePlan will reinforce the importance of having a truly connected network of cycle paths. Sydney’s bicycle network is currently fragmented and disjointed. The new NSW BikePlan will include the development of the Sydney Strategic Cycle Network, a high-standard, off-road continuous cycle routes that will link important destinations together such as employment centres, education centres, retail areas, and recreational venues. These locations have all seen considerable jobs growth, increased services (major medical, retail and entertainment activities), and residential development.

The major missing links

Twelve major missing links of the Sydney Metropolitan Strategic Cycle Network have been identified by the Roads and Traffic Authority and will be the focus of this study. Figure 1 below shows these major missing links. These major links will be off-street bicycle facilities completely separated from the motor-vehicle roadway and will be shared use paths (except for the southernmost part of the Naremburn to Harbour Bridge missing link which would join the cycle-only path on the western side of the bridge deck). Providing separated bicycle facilities along roadways is a key to increased perception of safety which is proven to encourage cycling as a means of transportation and recreation.

Some of the key attributes and expected uses of the cycle ways are summarised in Figure 2.
Regional Sydney’s current cycling patterns

Whilst bicycle travel accounts for only a small share of non-freight transport – 0.79% in 2005 – bicycle use has experienced significant growth for a number of years. In 2005, residents of Sydney metropolitan areas made around 120,000 trips per weekday, and 160,000 on weekend days, representing growth of 23% and 58% on 2001 levels.\(^4\) Relative to average annual growth in Sydney’s population of 1.3%, and in car trips of 1.8%, cycling is increasingly important to planning decisions.\(^5\)

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\(^4\) RTA 2008, ‘Cycling in Sydney – Bicycle ownership and use’ Sydney, NSW, Australia

Figure 2: Sydney Metropolitan Strategic Cycle - major missing links

<table>
<thead>
<tr>
<th>Strategic Link</th>
<th>Off-road cycleway</th>
<th>Expected utilisation</th>
<th>Commute</th>
<th>Education</th>
<th>Recreation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prospect to Blacktown</td>
<td>✓</td>
<td>L</td>
<td>●</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Moore Park pedestrian and cycle bridge</td>
<td>✓</td>
<td>Not estimated</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Naremburn to Harbour Bridge cycleway</td>
<td>✓</td>
<td>H</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Chatswood to Artarmon</td>
<td>✓</td>
<td>M</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Blacktown to Parramatta</td>
<td>✓</td>
<td>L</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>North Ryde to Macquarie Uni</td>
<td>✓</td>
<td>L</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Botany Bay to Maroubra</td>
<td>✓</td>
<td>L</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Huntleys Point pedestrian &amp; cycle bridge</td>
<td>✓</td>
<td>Not estimated</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>M7 links package</td>
<td>✓</td>
<td>Not estimated</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Guildford to Chester Hill</td>
<td>✓</td>
<td>H</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Lidcombe to Strathfield</td>
<td>✓</td>
<td>L</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Cooks River to Lilyfield</td>
<td>✓</td>
<td>H</td>
<td>●</td>
<td>○</td>
<td>●</td>
</tr>
</tbody>
</table>

Source: PwC calculations based on RTA estimations

L = Low
M = Medium
H = High

- 15% to 29% of total use
- 30% to 49% of total use
- more than 50% of total use
Social and recreational purposes are the primary purpose of most trips, particularly on weekends, reflecting the fact that cycling is a recreational activity as well as a mode of travel. This contrasts with other transport modes such as car travel, as shown in Figure 3.

Figure 3 - Trip purpose of car and bicycle travel

Source: Environmetrics and the City of Sydney, 2006, ‘Sydney cycling research: internet survey’

Almost half of all households own at least one bicycle, with students and the unemployed amongst the biggest users. Young people are more often bike users than older people, with those under twenty more than three times as likely to make 1 or more bicycle journeys per day.

All age groups, with the exception of 31-40 yr olds, are experiencing growth in bicycle usage. Of 1,150 Sydney residents recently surveyed, 40 per cent did not own a bike but were interested in cycling, almost equal to the number of current cyclists.

In the same survey, 41% of non-cyclists and 46% of potential cyclists agreed that one of the top reasons for not cycling was due to the perception of danger riding on the road.

International estimates of the value of cycling investments

The benefits of cycling have been long recognised and understood, but their valuation has always proved a challenge.

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7 Environmetrics and the City of Sydney, 2006, ‘Sydney cycling research: internet survey’
This is largely because bicycle facilities, like wilderness, a clean environment, and access of open and green spaces represent non market goods that are neither bought nor sold, with no market price for their existence. They are also usually non-rivalrous (their consumption by one individual does not prevent their consumption by another) and non-excludable (it is not possible to exclude people from using it once it is made available to one person). This gives bicycling facilities strong public good characteristics.

There have been several attempts to value cycling infrastructure over many decades, employing a range of valuation techniques. For instance:

- Buis (2000) valued cycling investments in Amsterdam, Botoga, and Morogoro by estimating expected avoided motorised journeys and safety impacts, and derived positive cost benefit ratios that were highest in cities that had not yet invested in cycling facilities. The cost benefit ratios ranged from 1.5:1 to 7:1\(^8\);
- Saelensminde (2002) provides positive net values for cycling investments in three Norwegian cities by monetising security and accident reduction, health benefits, and reduced parking costs. It also found that cities with the least amount of infrastructure in place see the most benefit from new infrastructure. The cost benefit ratios ranged from 3:1 to 14:1\(^9\);
- Fix and Loomis (1997) use a travel cost method to estimate the economic benefits to users of mountain bike trails in Moab, Utah, using revealed and stated preference techniques to measure consumer surplus and individual per-trip values using the travel cost method\(^{10}\);
- Maine Department of Transport (2001) examines the total economic impact of bicycle tourism by estimating the tourism market\(^{11}\); and
- Wittink (2001) examines the effectiveness of non motorised transport in facilitating economic growth, alleviating poverty, and improving the quality of life in urban areas in the Netherlands\(^{12}\).

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\(^11\) Maine Department of Transport (2001), Bicycle Tourism in Maine: Economic Impacts and Marketing Recommendations, Augusta, Maine Department of Transportation.
Scope of this report

PwC has been appointed by the NSW BikePlan Project Team, a joint project team of the RTA and Department of the Environment & Climate Change (DECC), to undertake an evaluation of the costs and benefits to the community of financial investment in cycling programs and projects in NSW.

This report provides qualitative and quantitative assessments and estimates the monetary value of the benefits of investing in the 12 major missing links of the Sydney regional cycle network.

Funding options

There is a range of funding options that could be explored for financing the proposed cycle ways. While funding arrangements are not within the scope of this review, some of the potential funding sources are summarised below for future consideration.

- Regional and Local Community Infrastructure Program, which provides one-off funding of $250 million in 2008-09 to local councils to stimulate growth and economic activity across Australia and support national productivity and community well-being. An additional $50 million is also available to councils and shires through a competitive process for projects that meet specified guidelines. This program was announced by the Australian Government on 18 November 2008.

- The NSW Government’s Climate Change Fund, which was established in July 2007, incorporating the expanded Water and Energy Savings Funds, the Climate Action Grant Program and some funding from the Environmental Trust. The fund will total $340 million over five years and provide financial support for communities, schools and business.

- The Environmental Trust, which is an independent statutory body established by the NSW Government to support exceptional environmental projects that do not receive funds from the usual government sources.

- The Climate Action Grants Program, which supports projects that assist the development and adoption of technologies, processes and practices that reduce greenhouse gas emissions or help the NSW community to adapt to the impacts of climate change.

- The Building Australia Fund, which was announced in the 2008-09, allocations from which are guided by Infrastructure Australia’s national audit and infrastructure priority list.

- PwC understands that Infrastructure Australia is keen to receive proposals for small projects, including cycling, that are likely to make a difference to the ongoing success of Australian cities. In addition to
the robust cost-benefit analysis contained in this report, a submission to IA also needs to demonstrate:

- the relevance of the cycling missing links to the new NSW BikePlan strategy;
- the appropriateness of the BikePlan in tackling congestion, protecting the environment and promoting sustainable growth;
- the potential for future improvements in bicycle facilities such as the installation of bike racks or cycle lockers around stations, etc; and
- how delivery issues for the project have been considered, such as funding, and governance arrangements.

The approach to this review

This report is divided into three parts:

The first part is a **Benefits Review** – identification and analysis of the most contemporary and relevant available information on the range of individual and community benefits of cycling, and their value.

The second part is a **Cost Benefit Analysis** (CBA) of all relevant quantifiable costs and benefits, clear articulation of credible, informed, objective assumptions and a comprehensive range of sensitivity tests. The CBA considers:

- new cyclists: the number of people who would switch from car journeys, public transport and walking to cycle journeys as a direct response to the building of the missing link infrastructure and/or are encouraged to undertake new cycle trips as a result of the new cycle ways;
- current cyclists: existing cyclists that will use the new facilities;

A range of impacts are indentified and monetised including:

- decongestion benefits;
- savings in user cost
- parking costs savings
- travel time savings
- health benefits
- air pollution reduction
- noise reduction
- infrastructure provision
- greenhouse gas reduction

The third part is a **Social Capital Analysis** – Not all of the benefits of cycling are economic benefits nor are all measurable. This part examines the social capital value of cycling investments, comparing cycling activities with other means for achieving a given trip purpose.
2 Benefits of cycling

There are a wide range of benefits associated with the promotion of cycling and the improvement of cycling facilities ranging from improvements in health promotion, environmental protection, alleviation of urban traffic congestion, and improved social cohesion.

These benefits accrue to:

- existing cyclists whose current levels of riding can increase if they have access to more attractive facilities and/or existing facilities are extended to accommodate more, or better cycling routes;
- potential cyclists, for whom the probability of cycling is increased due to more attractive facilities and/or the location of new facilities in their close proximity or proximity around facilities to which they are likely to attend; and
- if new cycling investments reduce car use, benefits also accrue to the wide community which benefits from any decrease in road congestion and any associated negative externalities.

For individual cyclists, the principal benefits of cycling relate to improved health, reduced transport expenses and lifestyle enhancements.\(^{13}\)

For the wider community, the benefits relate to any reduction in congestion and pollution, improved urban liveability, and any financial savings that arise from the deferral of other transport investment or the protection of access routes that might be required by Governments in the future (Figure 4).

If pedestrians are also to use cycle ways, they would also accrue the benefits outlined for cyclists.

\(^{13}\) Bauman A., Rissel C., Garrard J., Ker I., Speidel R., Fishman E., 2008 Cycling: Getting Australia Moving: Barriers, facilitators and interventions to get more Australians physically active through cycling, Cycling Promotion Fund, Melbourne.
These changes generate a series of financial, social, and environmental impacts that can be valued and compared to the cost of cycleway infrastructure investment. These impacts are illustrated in Figure 5 and described further below. Some social benefits, such as improved health outcomes and reduced probability of crash risk also have a financial component as they are valued at least in part by the cost savings they can deliver.

Figure 5: Cycling sources of value

![Fig. 5: Cycling sources of value](image)

Financial Benefits

For short-distance travel, bicycles are often faster than other modes such as cars or trains, and are certainly quicker than walking. This is particularly the case in urban areas and/or for travel of less than 5 kilometres.

Figure 6 below shows the estimated average journey time against distance by mode in the urban environment\(^{14}\), and shows that bicycles have the lowest travel time than any other mode for journeys up to around 4.5 kilometres.

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Parking cost savings

Commuters switching their car for a bike save the parking cost as usually up to 20 bicycles can be stored in the space required for one automobile, and bicycles are often stored in otherwise unused areas. Parking cost savings depend on marginal impacts. In the short run, reduced automobile trips may simply result in unoccupied parking spaces, but many destinations have parking problems that decline if parking demand is reduced. Over the long run, reduced parking demand allows property owners to avoid expanding parking capacity, or existing parking supply can be rented, leased or converted to other uses.

Reduced traffic congestion

One of the greatest potential value sources of improved cycling opportunities is the scope to substitute car trips, decreasing congestion and generating a range of environmental benefits such as improved air quality, and reduced consumption of non-renewable energy sources.

The environmental impacts of congestion are discussed further below, but congestion costs themselves typically refer to the cost of time losses experienced by other road users as a result of a motorists’ decision to drive. Congestion sees road users themselves incur higher vehicle operating costs

15 Victoria Transport Institute, 2004, Quantifying the benefits of non-motorised transportation for achieving mobility management objectives, p.10.
and longer trip times; as well as imposing additional delays and costs on other road users.  

The costs of congestion are considerable, with the Bureau of Transport and Regional Economics (BTRE) recently estimating the annual cost of congestion to the Australian economy at $9.4 billion\(^{16}\) and expected to rise to $20 billion by 2020. Figure 7 below shows estimated congestion costs for each Australian capital city. Congestion costs are also the highest in Sydney compared to other capital cities. By 2020, Sydney’s congestion costs are forecast to worsen, both in absolute terms and compared to growth in congestion costs in other capital cities. Modelling by the Centre for International Economics estimated congestion costs for Sydney of $12.1 billion in 2005, rising to $16.6 billion by 2020.\(^{18}\)

Such an increase in traffic volumes will lead to a substantial increase in congestion delays and have major adverse implications for mobility and amenity.

Figure 7 – Average unit costs of congestion for Australian metropolitan areas in 2005 and projected in 2020


\(^{17}\) Bureau of Transport and Regional Economics, 2007 Estimating urban traffic and congestion cost trends for Australian cities, Working Paper 71, Department of Transport and Regional Services, Canberra, Australia, p.16.

There are genuine opportunities for cycling trips to replace certain car trips with latest ABS statistics showing that 52% of the Australian car journeys to work are less than 5km each day\textsuperscript{19}. Journeys to school are also substitutable for trips involving older children, with a UK study finding that during school opening and closing times one in five of all cars on the road are on a school run\textsuperscript{20}. A common assumption is that 60 percent of all cycling trips are utilitarian in nature and are substituting for a car trip.\textsuperscript{21}

If substitution is achieved, the gains can be considerable. A recent study in the United Kingdom\textsuperscript{22} estimated that an adult switching from a car to a bicycle for a return journey of 3.9 km each way, on 80 days a year in an urban area generates annual savings of £137.28 ($320) through reduced congestion.

The value of substituting car with cycle trips is higher in areas of greater congestion, creating greater savings for cycling investment in cities than in rural areas. A US study\textsuperscript{23} estimates the saving per mile is USD 13 cents in metropolitan areas and USD 8 cents in suburban areas.

Estimating congestion cost savings as a result of cycling is complex, given the wide variances in the motivation for cycling and differences in traffic conditions for those routes that substitution may be achieved.

For instance, it has long been recognised that reduced congestion benefits need to be tempered by ‘induced demand’. This refers to the fact that reduced traffic congestion from construction of new cycleway facilities may be at least partly consumed by other drivers making additional trips or lengthening existing trips which were previously suppressed due to congestion. This means that any reduction in congestion, and subsequent energy and pollution benefits, are likely to be small.\textsuperscript{24}

\textit{\textsuperscript{19} Cycling Promotion Fund, 2008, Economic benefits of cycling for Australia, Auburn, Victoria.}

\textit{\textsuperscript{20} Valuing the benefits of Cycling, Cycling England, SQW report, May 2007}


\textit{\textsuperscript{22} Valuing the benefits of Cycling, Cycling England, SQW report, May 2007}

\textit{\textsuperscript{23} Transportation Research Board, 2006, Guidelines for Analysis of Investments in Bicycle Facilities, NCHRP Report 552, p.39.}

\textit{\textsuperscript{24} Krizec op. cit, p. 240.}
Roadway cost savings

Depending on the extent of any substitution between car and cycle trips, increases in bicycle trips has the potential to reduce road maintenance costs, as bicycles produce only insignificant wear and tear on roads.

A potentially more significant source of road cost savings is derived from using cycle ways for preserving land for right-of-way passage which may be required for future infrastructure expansion. Placing a bicycle track along a right-of-way corridor is a relatively inexpensive way of ensuring a transportation use for the corridor, which provides user benefits rather than allowing the land to lie fallow\(^25\).

Savings in user cost

The replacement of shorter car trips with cycle trips can have a positive impact on reducing vehicle operating costs. For instance, vehicle operating costs tend to be about 50% higher for short urban trips, due to cold starts (before the vehicle engine has warmed up), and congestion.

Fixed vehicle costs (costs that vehicle owners pay regardless of how much a vehicle is driven such as registration, insurance and depreciation) average about $5 per day\(^26\). These savings are in addition to those associated with any reduction in congestion.

Social Benefits

Improved health

Cycling is an effective and enjoyable form of physical activity, improving cardiovascular fitness, using all the major muscle groups, strengthening bones and helping prevent osteoporosis, improving circulation, relieving the effects of rheumatoid arthritis and, helping people cope better with stress\(^27\). There have been a range of recent studies that have linked cycling with improved health outcomes.


\(^{26}\) Victoria Transport Institute, 2004, Quantifying the benefits of non-motorised transportation for achieving mobility management objectives, p.11.

\(^{27}\) Australian Bicycle Council, 2002, ‘Review of costs benefit analysis methodology applied to road transport projects’, Meeting 12.
• an American study has shown a strong link between time spent driving and obesity\textsuperscript{28} with every additional 30 minutes spent in a car each day translating to a 3 percent greater chance of being obese;

• in terms of riding to work trips, a 2000 Danish study provided evidence that cycling to work reduces all-cause mortality risk;\textsuperscript{29}

• a 2006 study of 7,000 Australians showed that those who drive a car to work are 13\% more likely to be overweight or obese;\textsuperscript{30}

• the National Preventive Health\textsuperscript{31} taskforce estimated that the financial cost of obesity in Australia – not including overweight – was $8.3 billion in 2008.

• the WHO has shown that cycling is an effective method of reducing depression and anxiety\textsuperscript{32}.

The costs of inactivity in Australia estimated by Econtech show that physical inactivity costs $1.5 billion annually (Figure 8)\textsuperscript{33}.

Recent international estimates of the annual costs of inactivity include:

• $US19 per capita in hospital charges alone in Washington State,\textsuperscript{34} $US78 per capita in South Carolina,\textsuperscript{35} and $US79 per capita in Georgia.\textsuperscript{36}

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\textsuperscript{29} Andersen, LB, Schnohr, P, Schroll, M & Hein, HO, All-cause mortality associated with physical activity during leisure time, work, sports, and cycling to work, Archives of Internal Medicine; Jun 12, 2000; 160, 11; pg. 1621


\textsuperscript{31} Based on work by Access Economics, 2008. The growing cost of obesity in 2008: three years on, Canberra: Diabetes Australia.


\textsuperscript{33} Econtech, 2007 Economic modelling of the net costs associated with non-participation in sport and physical activity, Prepared by Econtech Pty. Ltd. for Medibank Private.


\textsuperscript{35} Powell, Greaney, Huang, Whitt (1999), Physical Activity in South Carolina, Columbia, University of South Carolina School of Public Health.
• $US100 per capita in otherwise avoided costs for treating diseases and conditions in Minnesota;\(^37\) and

• An average of $US128 per capita for those individuals reporting lack of physical activity across various studies.\(^38\)

\(^{37}\) Garrett, Brasure, Schmitz, Schmitz (2001), The Direct Cost of Physical Inactivity to a Health Plan, St. Paul Minnesota, Minnesota Department of Health.


While increasing rates of cycling has health benefits, it is important not to over-estimate the benefits of cycling. For instance, if increases in cycling reflect a switch in the type of physical activity rather than the generation of additional physical activity, the health benefits of cycling can be overstated\(^{39}\).

Estimating a health case, cost based reason for bicycling facilities requires evidence:

• of a relationship between the built environment and the levels of cycling;
• that the lack of physical activity imposes a financial burden on society;

that improved physical activity does reduce health care costs; and

that improved cycling facilities will attract cyclists and that behaviours are likely to be changed and maintained over time.\(^{40}\)

Ultimately the aim is to establish what change in the amount, intensity, or duration of exposure to cycling is associated with a change in risk of a specific health outcome.

**Community building**

Automobile-oriented transport tends to result in community development patterns that are suboptimal for other community objectives. Wide roads and heavy traffic tend to degrade the public realm (public spaces where people naturally interact) and in other ways reduce liveability whereas reduced vehicle traffic tends to increase neighbourly interactions and community involvement.

Some of the important community benefits of improved cycling infrastructure are:

- affordable price: a bicycle can be purchased and maintained for a modest price and is also energy efficient;
- equity of access issues, as it is available to all members of the community,
- safer routes to schools for children (cycling also plays a role in providing more independence to children);
- social inclusion in cases where it enables communities without access to cars or public transport to connect with each other,
- less congested routes to work;
- ability to choose alternative means of getting to work; and
- encourage the development of local shops and other community facilities.

These benefits are valued later in this report in terms of the impact of cycling activities in contributing to enhanced social capital in communities.

**Reduced crash risk**

Investments in off-road cycling infrastructure both reduce the probability of road crashes, and reduce the fear of crash, both of which improve the satisfaction of cyclists.

The UK Department for Transport recommends including journey ambience impacts in assessments of cycle ways. For instance, the ‘fear of potential accidents’ is considered by the UK Department for Transport when

\(^{40}\) Krizec, 2007 op. cit., p. 1.
evaluating cycling benefits\textsuperscript{41}, which is seen to greatly improve the attractiveness and safety of cycling. This is consistent with the findings of the Transportation Research Board\textsuperscript{42}, which found that bicycle commuters are willing to spend, on average 20.38 extra minutes per trip to travel on an off-street bicycle trail when the alternative is riding on a street with parked cars.

Whether or not increases in cycling result in fewer or more cycling accidents depends in part of the nature of cycling facilities, their proximity to road traffic, and other factors such as the presence of cycle commuters lanes for an entire cycle trip, rather than only part thereof.

A Copenhagen study found that between 1990 and 2000, the level of cycle traffic increased by 40% while the number of accident fell by 25%\textsuperscript{43}. In the Netherlands between 1980 and 1998, there was a 30% increase in cycling and a 54% fall in cyclist fatalities\textsuperscript{44}. In Australia, the Cycling Promotion Fund has shown that if cycling doubles, the risk per kilometre falls by 34%\textsuperscript{45}.

However, this may not be the case where cycle ways are along the roadside, and for this reason, some studies will assume there will be no change in the number of cyclist accidents as cycling increases\textsuperscript{46}.

Care must also be taken when linking variations in cycling crash rates to dedicated cycle ways, given changes to cycling safety over time that have occurred as a result of increased helmet use and better education.

Overall, it is believed that if promotion of active commuting is accompanied by suitable transport planning and safety measures, cyclist commuters are likely to benefit from the “safety-in-numbers” effect\textsuperscript{47}. This may particularly be the case for off road facilities.


\textsuperscript{43} Ibid.

\textsuperscript{44} “The Dutch Bicycle Master Plan, description and evaluation in an historical context”, 1999, Ministry of transport (NL)

\textsuperscript{45} Bauman A., Rissel C., Garrard J., Ker I., Speidel R., Fishman E., 2008 Cycling: Getting Australia Moving: Barriers, facilitators and interventions to get more Australians physically active through cycling, Cycling Promotion Fund, Melbourne.

\textsuperscript{46} Nordic Council, 2005, CBA of cycling, p.16.

While not reflecting the results of a randomly selected set of countries, Figure 9 does seem to show an inverse relationship between bicycle use and casualties.48

**Figure 9 – Relation between the number of cyclists and the number of casualties among cyclists involved in road accidents**

![Graph showing inverse relationship between bicycle use and casualties.]


### Improved mobility options

Cycling provides an opportunity to make trips that would take more time to walk and access services that would be otherwise too far to use, particular for those in the community that do not have access to a private vehicle.

Therefore, improving cycling infrastructure helps provide alternative transport modes to increase the mobility of society, particularly those that rely on non-motorised modes of transport.50

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49 Hyden, C., Nilsson A. & Risser R., 1998, How to encourage walking and cycling as alternatives to short car trips and improve traffic safety at the same time.

50 Victoria Transport Institute, 2004, Quantifying the benefits of nonmotorized transportation for achieving mobility management objectives, p.15.
Environmental Benefits

Reduced noise

While no mode of transport is entirely noise free, bicycling is generally considered to be a virtually noiseless form of transport compared to the noise levels generated by motor vehicles.

Reduced air pollution

Bicycling effectively produces no air pollution, aside from the very small increase in CO₂ emissions associated with an increase in cyclists' metabolic rate. Even this very small increment is preferable to the form of CO₂ emissions from motorised forms of transport as it is produced from renewable sources (food) rather than from fossil fuels.

This compares to motor vehicles, which are a major contributor of air pollutants, accounting for more than 50% of the emissions of oxides of nitrogen (NOx), carbon monoxide (CO) and almost half the emissions of hydrocarbons in Australia each year.⁵¹

There is mounting epidemiological evidence that air pollution generated by road traffic has adverse health effects for the community including:

- Acute effects, which occur due to short-term variation in pollution exposure and manifest as symptoms and variations in bodily functions, principally respiratory and cardiac functions, and include exacerbations of pre-existing illness; and
- Longer-term effects, which are cumulative effects of exposure to air pollutants and may result in either the initial manifestations of new illnesses, such as chronic lung disease, or the persistence of pre-existing illnesses.

A recently released BTRE study found that in 2000, vehicle related ambient air pollution accounted for between 368–1756 morbidity cases (cardiovascular and respiratory disease) and between 339–762 early deaths in Sydney⁵². Sydney is estimated to account for around 39 per cent of the Australia wide morbidity and mortality cases attributable to motor vehicle related air pollution.

The BTRE has costed the adverse health impacts attributable to emissions of these pollutants from motor vehicles. In 2000, PM10 emissions from motor

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vehicles in Sydney amounted to 4750 tonnes\textsuperscript{53}. These emissions were associated with a total cost of between $613 million and $1.5 billion (the large confidence interval reflects the difficulty in separating motor vehicle emissions from background pollutant levels and epidemiological uncertainties). Working off the central cost estimate, Sydney incurred a cost of $218 105 per tonne of PM10 emitted (measured in 2000 dollar terms). In today’s dollar terms, that cost is nearly $257 000 per tonne of PM10.\textsuperscript{54}

In urban area, emissions reductions can be large because they usually replace short, cold-start trips for which internal combustion engines have high emission rates, so each 1% of automobile travel replaced by walking or cycling decreases motor vehicle emissions by 2% to 4\textsuperscript{55}.

**Reduced greenhouse gas emissions**

The RTA identified three potential sources of greenhouse gas reduction from promoting and providing for cycling\textsuperscript{56}. These are:

- substituting kilometres travelled in motor vehicles with bicycle trips;
- replacing cars (which have significant embedded emissions) with bicycles in the transport fleet; and
- improving traffic flow through reducing congestion or improving space management.

Australia wide, domestic transport accounts for 14.4 per cent of Australia’s total greenhouse gas emissions, 88 per cent of which result from road transport compared to 2 per cent for rail transport. The cost of greenhouse gas emissions from road transport in Sydney is estimated at $144.8 million for 2005, and is forecast to rise to $186.9 million in 2020.\textsuperscript{57}

Cycling offers substantial potential to lower emissions in the passenger transport sector\textsuperscript{58}. In Australia, cars produce an average of 0.3 kg of CO\textsubscript{2} per

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\begin{footnotesize}


55 Victoria Transport Institute, 2004, Quantifying the benefits of nonmotorized transportation for achieving mobility management objectives, p.12.

56 The role of Bicycles in Greenhouse Gas Reduction, 2000 RTA report.


58 Economic Benefits of Cycling for Australia, Cycling Promotion Fund, June 2008
\end{footnotesize}
km travelled\(^{59}\). As a consequence, for each kilometre travelled by bike instead of a car; a saving of approximately 0.3 kg of CO\(_2\) could be achieved.

Figure 10 below shows the greenhouse gas emissions from different forms of transport in Australia\(^{60}\).

![Figure 10 – Kg of greenhouse gas per person per Km from different forms of transport](image)

Tourism, retail and other opportunities

Improved cycling conditions and shifts from motorized to non-motorised modes can increase economic productivity and development by creating more economically efficient land use patterns. For example, cyclists are an important market segment for small and local business. They tend to travel for shorter distances, buy less at once and buy more frequently at smaller businesses than motorised customers.

In addition, cycling infrastructure can increase nearby property values and help attract residents and even businesses that value environmental quality, physical fitness and outdoor recreation\(^{61}\). The concept of “liveability” is a relatively ambiguous term. It is usually acknowledged that the ease by which residents can travel by cycling is a critical component of this concept\(^{62}\).


\(^{60}\) Australian Greenhouse office [online at http://www.environment.gov.au/settlements/gwci/transport.html]

\(^{61}\) Victoria Transport Institute, 2004, Quantifying the benefits of nonmotorized transportation for achieving mobility management objectives, p.15.

Communities well endowed with non-motorised infrastructure, either in the form of sidewalks, bicycle paths, or compact and mixed land uses are hypothesised to be more liveable than those without.

This is partly associated with the option value of being able to utilise specific facilities, whether or not people actually use them. For instance, it is possible that some people may pay a premium to live near a bike path despite not cycling themselves because they may want to in the future.
3 Cost benefit analysis of missing cycle way links

The benefits of cycling are largely a function of the amount of cycling. They will invariably depend on finer details such as the location, purpose, person cycling, and characteristics of the facility being used. The overarching issue is reliably determining an economic value for a facility for which there is no market value and little data for its use.

This Cost Benefit Analysis (CBA) develops a series of quantifiable benefit streams for 9 of the 12 proposed missing link cycle ways based on information provided by the RTA and an extensive literature review on cycling benefits.

While the methodology largely follows the logic of the RTA's economic framework for quantifying benefits of cycling, we have made several departures in the areas of:

- health
- greenhouse gas emission reduction
- noise reduction
- induced demand

The cost benefit analysis (CBA) adopts a discounted cash flow model over a 20 year evaluation period following the construction of the new cycle ways. The model assumes that no benefits are realised until all cycleway construction is complete. Hence it excludes any economic activity benefits that result from the injection of investment into the regions during the construction phase. It also assumes that there is no substantive utilisation of earlier completed cycle ways, given uncertainties around the timing and sequencing of cycleway construction.

The future cost streams are discounted using a 7% discount rate (real) and the following measures of economic performance are reported:

- Net present value (NPV);
- Benefit cost ratio (BCR);
- NPV/investment; and
- Economic Internal Rate of Return (EIRR).

Base Case

The base case adopts a ‘do nothing’ approach. This implies that no costs would be incurred if these projects were not constructed (i.e. no avoided costs), and that demand for cycling would increase in line with historic trends.

This base case is then subtracted from the incremental change scenarios that contain the construction of the nine projects. This ensures that only
incremental costs and benefits that are directly attributable to the nine missing link projects are captured in the economic evaluation.

**Project capital costs**

The projected capital costs include land acquisition and project costs, covering construction, design and project management, as shown in Figure 11.

The minimum cost scenario represents the initial engineering cost estimates which have an average confidence interval of 70% (P70). The maximum cost scenario represents a full risk adjusted capital cost (i.e. P100). The medium cost scenario represents the mid point between these upper and lower bounds. Figure 10 show fixed capital costs inflated to December 2008 prices.

It does not include any allowance for ancillary services such as building showers, change rooms, bicycle racks, and the like. Nor does it include bicycle purchase costs, or costs involved in the promotion of the new cycle ways.

The cost of ancillary services is not part of the missing link cycle ways plan, and might arguably form an alternative option for promoting cycling as could be bicycling subsidies. Promotion costs, however, could be an issue, and these costs may be later incorporated into this analysis as the proposal is further progressed.

**Figure 11: Fixed Capital Costs, 2008 undiscounted ($million)**

<table>
<thead>
<tr>
<th>Project</th>
<th>Minimum Cost Scenario</th>
<th>Medium Cost Scenario</th>
<th>Maximum Cost Scenario (P100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Prospect to Blacktown</td>
<td>5.0</td>
<td>5.3</td>
<td>5.6</td>
</tr>
<tr>
<td>2 Moore Park pedestrian / cycle bridge</td>
<td>Not included</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Naremburn to Harbour Bridge cycleway</td>
<td>25</td>
<td>30.4</td>
<td>35.7</td>
</tr>
<tr>
<td>4 Artarmon to Chatswood</td>
<td>13.9</td>
<td>16.9</td>
<td>19.9</td>
</tr>
<tr>
<td>5 Parramatta to Blacktown</td>
<td>6.0</td>
<td>7.3</td>
<td>8.6</td>
</tr>
<tr>
<td>6 North Ryde to Macquarie Uni</td>
<td>5.0</td>
<td>6.1</td>
<td>7.1</td>
</tr>
<tr>
<td>7 Botany Bay to Maroubra</td>
<td>7.0</td>
<td>8.5</td>
<td>10.0</td>
</tr>
<tr>
<td>8 Huntleys Point pedestrian / cycle bridge</td>
<td>Not included</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 M7 link package</td>
<td>Not included</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Guildford to Chester Hill</td>
<td>6.0</td>
<td>7.3</td>
<td>8.6</td>
</tr>
<tr>
<td>11 Strathfield to Lidcombe</td>
<td>4.0</td>
<td>4.9</td>
<td>5.7</td>
</tr>
<tr>
<td>12 Cooks River to Lilyfield</td>
<td>10.0</td>
<td>15.0</td>
<td>20.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>81.9</strong></td>
<td><strong>101.6</strong></td>
<td><strong>121.2</strong></td>
</tr>
</tbody>
</table>
Demand forecasts

The modelling draws upon detailed demand forecasts provided by the RTA which identifies the potential range of people which would be expected to switch from car journeys to cycle journeys in response to the building of this missing link infrastructure. A medium demand scenario has been developed based on this RTA work, representing the mid-point between the upper and lower bounds forecast by the RTA. These new cycle journeys represent an incremental increase in the total number of cyclists using the Sydney cycle network. The full methodology used to calculate this demand is outlined in Appendix B – Demand Forecasting methodology.

These demand forecasts were augmented to ensure other new users, not just those diverting from car trips, were also captured. The key assumptions underlying the demand forecasts include the following:

Forecast utilisation includes demand from the following groups:

- New cyclists for trips that are diverted from private car trip.
- Demand from new cyclists for trips that are diverted from public transport and walking trips, derived from the forecast increase in diverted car trips, pro-rated in accordance with the Sydney transport mode share for public transport and walking trips$^{63}$.
- Induced cycling journeys that would not have taken place had the infrastructure not been created. This includes people that take up cycling for recreational and exercise purposes, in effect creating new cycling journeys. Because these people don’t represent a mode shift, no benefits can be allocated that relate to avoided costs for car and public transport travel. However, these people do enjoy the health benefits. Insufficient data exists to accurately gauge this demand. A conservative assumption has been made that this will lead to a 5% increase in total demand and applies only to the calculation of health benefits.
- Induced pedestrian journeys that would not have taken place had the infrastructure not been created. As with new cyclists above, this includes people that take up walking on the new cycle ways for recreational and exercise purposes rather than being inactive. A conservative assumption has been made that this will lead to a 2% increase in total demand and applies only to the calculation of health benefits.

Most recently available transport mode share data from the Transport Data Centre (2002) for Sydney indicates that car travel accounts for 69.7% of all journeys in Sydney. This analysis assumes that demand for cycling generated by the missing links projects accounts for 69.7% of total demand and demand from displaced public transport and walking trips is 30.3% of demand.
Exclusions

Demand from current cyclists is not included in forecast utilisation, although it is expected that existing cyclists will also use the new cycle ways. Demand from this subgroup is excluded from the quantitative analysis given that existing cyclists already receive health benefits associated with cycling and their expected displacement of motorised transport trips is likely to be limited. This group are expected to incur only qualitative benefits associated with improved cycling enjoyment and improved utilitarian outcomes.

Demand from displaced pedestrian trips for cycling trips is also excluded from the demand forecasts, with no benefits assigned to this group.

Occupancy rates

For demand associated with displaced car trips, a conservative car occupancy rate of one is assumed. The RTA specifies an average occupancy of 1.12 during peak and 1.97 outside peak and business hours which would reflect higher occupancy on weekends and car pooling by commuters. In principle, dividing the demand pool into commuting versus leisure trips, and weekday versus weekend trips would be desirable. However, the key mechanism for segmenting the demand pool in this way is by differentiating the occupancy rate. In this case, demand forecasts for the proposed cycle ways are based on trip numbers, not cyclist numbers. Differentiating the demand pool by commuter and non-commuter trips is believed to introduce unjustified degrees of errors in the results. Keeping the occupancy rate at 1 also helps ensure that the empirical results are conservative given uncertainties about car trip displacements for some trips in the demand forecasts.

Moreover, using an occupancy rate of more than one would result in the double counting of the number of car trips that are removed from the road. If the transfer of a car trip to a cycling trip means that more than one person is cycling, then the additional person would experience health benefits, and using an occupancy rate of only one means that these benefits are not captured. This review has decided to err on the side of caution and accept that the health benefits of the cycle ways may be slightly understated to ensure that the larger error of double counting the reduction in vehicle and environmental costs is not made.

Ramp-up of the demand

A conservative ramp up has been used to mirror the delay in take up rate for new transport infrastructure developments. It is assumed that only 75% of potential benefits accrue to the project in the first full year after opening (2013), 85% in the second year (2014) and 95% in the third year (2015). From 2016 onwards it is assumed that 100% of the projected benefits are realised (Figure 12).
Figure 12: Total expected demand by 2016

<table>
<thead>
<tr>
<th>Demand scenario</th>
<th>Daily trips</th>
<th>Diverted km from car trips</th>
<th>Diverted km from non car trips</th>
<th>Total km diverted</th>
<th>Total bicycle km (incl. new cycling trips)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 5 km</td>
<td>5 – 10 km</td>
<td>Aver. daily km</td>
<td>Aver. daily km</td>
<td>Annual km</td>
</tr>
<tr>
<td>Low</td>
<td>10,030</td>
<td>2,060</td>
<td>45,540</td>
<td>65,337</td>
<td>23,848,063</td>
</tr>
<tr>
<td>Medium</td>
<td>11,595</td>
<td>2,525</td>
<td>53,722.50</td>
<td>77,077</td>
<td>28,133,016</td>
</tr>
<tr>
<td>High</td>
<td>13,160</td>
<td>2,990</td>
<td>61,905</td>
<td>88,816</td>
<td>32,417,970</td>
</tr>
</tbody>
</table>

Notes – Assumes average trip length for journeys <5km is 3km and for journeys 5km – 10km is 7.5km. Car mode share is 69.7% of total Sydney journeys (TDC 2002) Assumed induced cycling for recreational cycling, only used in the calculation of health benefits is 5% of total cyclists.

From 2016 onwards the assumed growth of new cyclists using the missing link is assumed 1.5% per annum. This assumption reflects projected population growth rates for Sydney and historic growth in transport modes. This assumption is considered conservative given the recent high growth and up-take in cycling across the Sydney network.

The components of demand and the benefits that arise from each are illustrated in Figure 13.

Figure 13: Components of new cycle way demand and associated sources of value
Quantification of costs and benefits

Parameters used in the evaluation are primarily driven by the changes that stem from replacing car, public transport or walking trips with cycling trips. A relationship therefore needs to be established between the replacement of car travel for bike travel. Based on TDC mode share data for Sydney, the RTA assumes:

- One bicycle KM trips replaces 0.65 car KM trips; and hence
- One bicycle KM trip replaces 0.35 walking, bus and train trips.

These effects relate to new and/or induced bicycle users and assume there is no suppressed demand for the forms of transport cycling is replacing.

This replacement relationship is used in generating the parameters of cost savings that are generated by replacing car trips with cycling trips. These parameters are then multiplied by the aggregate number of new bike kilometres travelled that is a direct result of the missing link infrastructure.

There are a number of key assumptions that will drive the user (existing and potential) and non-user (wider community) costs and benefits, which are later subject to sensitivity testing.

Decongestion

A number of institutions calculate decongestion cost savings. This is done by analysing the additional journey cost incurred when travelling in congested conditions against a hypothetical journey cost of zero congestion. Congestion costs are therefore a factor of both the volume of vehicles on the road and average traffic speeds. Therefore, any reduction in the number of cyclists which generate increased traffic speeds and reduced traffic volumes will result in decongestion cost savings.

The most recent decongestion cost calculations have been undertaken by CityRail and are specific to the Sydney network. They estimate that every one reduction in a car kilometre translates into road congestion savings of 37.36 cents.

It is important to distinguish between commuters and leisure cyclists in estimating decongestion impacts, given that cycling leisure trips are unlikely to displace any peak period car trips. To achieve this distinction, the model only accounts for decongestion benefits on weekdays using an annualised factor of 260 days per year. In this way, the model assumes decongestion benefits only arise for commuters. This conservative allowance is also important given the possibility that some of the decongestion will be replaced by new car trips that respond to the change in congestion conditions. This is

64 CityRail 2008, A Compendium of CityRail Travel Statistics, pg 74.
sometimes referred to as the ‘rebound effect’ or the response of ‘pent up demand’, whereby “less traffic generates more traffic”.

No additional allowance has been made for the rebound effect, given that the number of car trips that are displaced by the new cycle ways is not of an order of magnitude deemed likely to stimulate or unleash pent up journeys. It is not appropriate to discount the value of decongestion benefits outlined in the literature, and this reasoning suggests that it is also inappropriate to discount the amount of vehicle kilometres to which it applies.

Using the replacement value of 65% (implying that 1 bicycle kilometre reduces car KM by 0.65), the decongestion cost savings attributable to new cyclists can be calculated by 65% * 37.36 cents. This generates a saving of 24.28 cents per bicycle kilometre in Sydney.

Savings in car user costs

Savings in car user costs are based on the premise that people cycling instead of driving avoid vehicle operating costs which include fuel, tyre repair, maintenance and depreciation. Given public transport in Sydney is highly subsidised; it is also possible that some people cycling instead of catching public transport actually reduce the subsidy required. However, for the purpose of this study it has been assumed that there are no avoided public transport cost savings given the under-utilisation of the public transport network outside of the peak and the large fixed costs of public transport which are typically unaffected by changes in marginal use. Furthermore, spare capacity on public transport created by new infrastructure is often redispersed within the existing network rather than being discontinued, effectively resulting in no net change to public transport costs.

The latest estimates suggest car operating costs are 23.5 c/km. These user costs are then weighted against the Sydney transport mode share (TDC 2002) to generate a weighted saving in user costs per bicycle kilometre of 16.39 cents (Figure 14).

![Figure 14: User cost savings](Image)

<table>
<thead>
<tr>
<th>Mode Share</th>
<th>User Cost / km</th>
<th>User cost savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car VOC</td>
<td>69.7%</td>
<td>0.235</td>
</tr>
<tr>
<td>Public Transport Fare</td>
<td>10.9%</td>
<td>0.00</td>
</tr>
<tr>
<td>Walk + Other</td>
<td>19.4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>


Parking cost savings

The RTA (2002) estimates parking user cost savings of 1c per bicycle kilometre. This represents an avoided cost of parking facility infrastructure and maintenance.

This figure has been inflated using Sydney CPI to Sept. 2008 prices. This estimate acknowledges that the impact upon parking costs will be low for cyclists.

Bicycle crash costs

Following the RTA methodology, bicycle crash costs have been calculated by looking at the number of accidents per million kilometres travelled (MKT) for cycling and driving. Using the unit accident cost of $63,100\(^{67}\) per accident, the accident costs per MKT for cycling and driving can be calculated. Crash costs include three main components, human costs, vehicle costs and general costs. As such, the unit cost of accident is similar for cars and bicycle crashes. Therefore, the incremental cost for cycling is estimated at 8.9 cents per bicycle kilometre travelled for Sydney (Figure 15).

In addition, due to the off-road pattern of the missing links cycle ways, the exposure to risk for bicyclists will decrease. Assuming that 56% of reported bicycle crashes occur in intersections\(^{68}\), and assuming the new missing links will carry a certain number of intersections, the expected number of bicycle crashes has been reduced by 44% (corresponding to the 44% of crashes avoided as cyclists would ride off-road)\(^{69}\). This assumed reduction in the number of bicycle crashes remains highly conservative as other factors could further reduce the crash costs such as the increasing use of helmets.

![Figure 15: Car and bicycle crash costs](image)

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of accidents</th>
<th>Million of kilometres travelled (MKT)</th>
<th>Number of accident per MKT</th>
<th>Unit accident cost ($/accident)</th>
<th>Accident cost per MKT ($/MKT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle travel</td>
<td>35.808</td>
<td>35,581</td>
<td>1.0064</td>
<td>63,100</td>
<td>63,503</td>
</tr>
<tr>
<td>Bicycle travel</td>
<td>684</td>
<td>283</td>
<td>2.4158</td>
<td>63,100</td>
<td>152,439</td>
</tr>
</tbody>
</table>

Calculation: \((152,439-63,503)/1,000,000= 8.9\) cents

---

\(^{67}\) RTA, Economic Manual Parameters (2007)

\(^{68}\) RTA 2003, Valuing the costs and benefits of cycling, 2003, pg 15.

\(^{69}\) It is recognised that the base line data on crash costs would have seen costs decline as the safety of cycling has been improved by various initiatives – such as the compulsory use of helmets, construction of dedicated cycle paths, improved safety campaigns, etc. - However these estimates are not based off an historical crash cost estimate that would otherwise introduce this bias.
Health benefits

There is a wide range of ways in which the health benefits to users of the missing cycle ways can be estimated. This report has already highlighted different approaches to estimating the costs in inactivity, which can be used to derive foregone costs.

This analysis employs two different methodologies for estimating the expected health benefits for new cyclists that are attracted due to the construction of the missing links. The RTA (2003) methodology is used for the main iteration of results, which estimates the expected health cost savings per bicycle kilometre associated with a reduction in premature deaths from heart attacks for men who cycle more than 6 hours per week.

This method has been chosen for the main iteration of results for its relative conservatism, given the uncertainties associated with the use profiles of cycle ways from the population of potential new cyclists.

This approach is considered to be highly conservative in that it excludes health cost savings that relate to less severe medical conditions or the benefits that accrue to cyclists that cycle for shorter durations.

This conservative approach is considered to be appropriate for two principal reasons.

- Firstly, demand for the cycle ways is arguably likely to exclude those that have been inactive for long periods of time, and for whom the health benefits of becoming active are the most considerable.
- Secondly, those that are most likely to use the new cycleways could already be relatively active and healthy. Hence some of the demand for the new cycleways may for some result from a transfer in physical activity from other forms of exercise to cycling.

Using updated assumptions and data relating to the missing cycle ways, health benefits are estimated at around $500,000 per annum once demand has ramped up to expected levels.

The methodology developed by the World Health Organisation (WTO) in its Health Economics Assessment Tool (HEAT) is used in the sensitivity analysis below. This methodology produces an annual benefit from an expected reduction in mortality due to increased physical activity, capturing a much wider range of causes of mortality and linking it to the total hours cycled per annum. This model is very sensitive to the distance that cyclists travel on average, with longer average trip lengths associated with greater benefits.

The WHO model uses a default value of around $0.6 in savings per kilometre cycled per individual cyclist per year, compared to the $0.012 per bicycle kilometre travelled which was estimated by the RTA in 2003.

Using the HEAT tool and inputting data and assumptions on the expected utilisation of the missing link cycle ways, the annual benefits at full utilisation are around $28 million per annum, which clearly far exceeds other methods for estimating changes.
Air pollution reduction

The cost of air pollution is assumed to be 2.45 cents per car kilometre travelled, based on the default externality values identified in the Australian Transport Council’s 2006 National Guidelines for Transport System Management in Australia (adjusted to 2005 dollars). Applying the replacement effect of 65% implies that the avoided cost of air pollution is 1.6 cents per bicycle kilometre in 2005 dollars. Using Sydney CPI to inflate to December 2008 dollars produced a value of 1.73 cents per bicycle km.

Noise reduction

Noise reduction benefits are difficult to quantify as they depend on location and the type of vehicle. Australian Transport Council’s 2006 National Guidelines for Transport System Management in Australia identifies the externality cost of noise from passenger vehicles of 0.78 cents per vehicle kilometre. Inflated to December 2008 prices give a value of 0.85 cents per bicycle kilometres.

Infrastructure (roadway) provision

The RTA (2003) assumes that roadway cost savings associated with the provision of new cycle ways are 3.3 cents per bicycle kilometre. This assumption was informed by work undertaken by AustRoads (1994) and the Sydney Future Directions Study (1991). Using Sydney CPI to inflate to December 2008 dollars produced a value of 3.9 cents per bicycle km.

Given that some of the demand for new cycle ways is generated by displaced public transport trips, it is possible that some displacement of public transport funding could also occur. However, given the scale of the cycle ways under review and their expected utilisation, the level of diversion of public transport trips is not considered to be sufficient to influence public transport investment decisions. This is particularly the case for NSW where there are already areas of underinvestment. Including a measure of deferment of public transport investment would inappropriately imply some element of redundancy.

Greenhouse gas reduction

The 2006 National Guidelines for Transport System Management in Australia specify a value of CO₂ emissions of 0.3 cents per vehicle kilometre travelled for 2005. Inflating using the Sydney CPI produces a value for 2008 of 0.33 cents. Using $20 as the proxy cost of carbon, this translates to a saving of 0.7 (this needs to change) cents per bicycle kilometre travelled.

---


Results

This analysis derives a net benefit of the new cycle ways of 48.22 cents per bicycle kilometre (Figure 16).

Figure 16: Estimated impact of cycling per bicycle kilometre travelled

<table>
<thead>
<tr>
<th>Benefits</th>
<th>(2008 ¢ / bicycle km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decongestion benefit</td>
<td>24.28</td>
</tr>
<tr>
<td>Savings in user cost</td>
<td>16.39</td>
</tr>
<tr>
<td>Parking cost savings</td>
<td>1.00</td>
</tr>
<tr>
<td>Travel time costs</td>
<td>0.00</td>
</tr>
<tr>
<td>Bicycle crash cost</td>
<td>-2.03</td>
</tr>
<tr>
<td>Health benefits</td>
<td>1.42</td>
</tr>
<tr>
<td>Air pollution reduction</td>
<td>1.73</td>
</tr>
<tr>
<td>Noise Reduction</td>
<td>0.85</td>
</tr>
<tr>
<td>Infrastructure provision</td>
<td>3.91</td>
</tr>
<tr>
<td>Greenhouse Gas Reduction</td>
<td>0.66</td>
</tr>
<tr>
<td><strong>TOTAL Net Benefit</strong></td>
<td><strong>48.22</strong></td>
</tr>
</tbody>
</table>

Note: Items with a negative produce an economic dis-benefit. * Any travel time costs incurred are assumed cancelled out by travel time savings enjoyed by existing cyclists on the network.

Combined with the demand forecasts and expected track configurations, the results indicate the construction of the nine missing link projects to be economically viable, producing a NPV of $29.84 million and BCR of 1.3.

Figure 17 below summarises the key results of the economic evaluation. Appendix A details the full cost and benefit streams used to derive these values.

Figure 17: CBA results

<table>
<thead>
<tr>
<th>Costs</th>
<th>Total ($m)</th>
<th>NPV ($m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost</td>
<td>102</td>
<td>95.1</td>
</tr>
<tr>
<td><strong>Benefits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decongestion benefit</td>
<td>105.50</td>
<td>46.52</td>
</tr>
<tr>
<td>Savings in user cost</td>
<td>99.98</td>
<td>44.09</td>
</tr>
<tr>
<td>Parking cost savings</td>
<td>6.10</td>
<td>2.69</td>
</tr>
<tr>
<td>Travel time costs</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bicycle crash cost</td>
<td>(12.40)</td>
<td>(5.47)</td>
</tr>
<tr>
<td>Health benefits</td>
<td>9.28</td>
<td>4.09</td>
</tr>
<tr>
<td>Air pollution reduction</td>
<td>10.55</td>
<td>4.65</td>
</tr>
<tr>
<td>Noise reduction</td>
<td>5.18</td>
<td>2.29</td>
</tr>
<tr>
<td>Infrastructure provision</td>
<td>23.86</td>
<td>10.52</td>
</tr>
<tr>
<td>Greenhouse gas reduction</td>
<td>4.03</td>
<td>1.77</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>252.08</td>
<td>111.15</td>
</tr>
<tr>
<td><strong>Residual</strong></td>
<td>60.94</td>
<td>13.76</td>
</tr>
<tr>
<td><strong>Total Benefits</strong></td>
<td><strong>313.02</strong></td>
<td><strong>124.91</strong></td>
</tr>
<tr>
<td><strong>Incremental Benefits</strong></td>
<td><strong>211.45</strong></td>
<td><strong>29.84</strong></td>
</tr>
</tbody>
</table>
These results incorporate the mid level capital expenditure forecasts, medium scenario demand forecasts and conservative health values scenario. The impacts of the alternate scenarios are treated through sensitivity analysis below.

**Sensitivity Analysis**

In addition to the specific sensitivity test required by the NSW Treasury and IA guidelines, a number of the key assumptions, alternate demand, capital expenditure and health benefits have also been tested. The results of these tests are displayed in Figure 18.

The key sensitivity for the purposes of this review is the discount rate, which for the main iteration of results is set at 7%. Arguably a discount rate of 4% could be more appropriate in this case in recognition of the social capital benefits that cycling trips generate (see Chapter 4 for further explanation). This would be consistent with international standards for assessing infrastructure, where the use of discount rates of around 3%-4% is commonplace in Europe for projects that have social importance and intergenerational value.

Using a 4% discount rate produces a BCR of 1.8.

### Figure 18: Sensitivity analysis

<table>
<thead>
<tr>
<th>Sensitivity Analysis</th>
<th>BCR</th>
<th>NPV</th>
<th>NPVI</th>
<th>EIRR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Discount Rate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4%</td>
<td>1.8</td>
<td>82.1</td>
<td>0.8</td>
<td>9.7%</td>
</tr>
<tr>
<td>7%</td>
<td>1.3</td>
<td>29.8</td>
<td>0.3</td>
<td>9.7%</td>
</tr>
<tr>
<td>10%</td>
<td>1.0</td>
<td>(2.3)</td>
<td>(0.0)</td>
<td>9.7%</td>
</tr>
<tr>
<td><strong>Capital Costs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum scenario</td>
<td>1.6</td>
<td>45.5</td>
<td>0.6</td>
<td>12.0%</td>
</tr>
<tr>
<td>Medium Scenario</td>
<td>1.3</td>
<td>29.8</td>
<td>0.3</td>
<td>9.7%</td>
</tr>
<tr>
<td>Maximum scenario (P100)</td>
<td>1.1</td>
<td>14.1</td>
<td>0.1</td>
<td>8.1%</td>
</tr>
<tr>
<td><strong>Car Replacement Rate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45%</td>
<td>1.2</td>
<td>15.5</td>
<td>0.2</td>
<td>8.5%</td>
</tr>
<tr>
<td>65%</td>
<td>1.3</td>
<td>29.8</td>
<td>0.3</td>
<td>9.7%</td>
</tr>
<tr>
<td>85%</td>
<td>1.5</td>
<td>44.2</td>
<td>0.5</td>
<td>11.0%</td>
</tr>
<tr>
<td><strong>Demand Scenario</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1.1</td>
<td>12.9</td>
<td>0.1</td>
<td>8.2%</td>
</tr>
<tr>
<td>Medium</td>
<td>1.3</td>
<td>29.8</td>
<td>0.3</td>
<td>9.7%</td>
</tr>
<tr>
<td>High</td>
<td>1.5</td>
<td>46.8</td>
<td>0.5</td>
<td>11.2%</td>
</tr>
<tr>
<td><strong>Decongestion Benefits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No decongestion benefits (i.e. assumes suppressed road demand)</td>
<td>0.8</td>
<td>(16.7)</td>
<td>(0.2)</td>
<td>5.3%</td>
</tr>
<tr>
<td><strong>Health Benefits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTA Value</td>
<td>1.3</td>
<td>29.8</td>
<td>0.3</td>
<td>9.7%</td>
</tr>
<tr>
<td>Mean who</td>
<td>3.1</td>
<td>198.4</td>
<td>2.1</td>
<td>21.9%</td>
</tr>
<tr>
<td>Full WHO</td>
<td>2.0</td>
<td>91.3</td>
<td>1.0</td>
<td>14.7%</td>
</tr>
</tbody>
</table>

Evaluation of the costs and benefits to the community of financial investment in cycling programs and projects in New South Wales

PricewaterhouseCoopers | 43
Other key observations from the sensitivity tests are as follows:

- The results are robust at 10% discount rate, indicating:
  - robust at P100 capex forecasts (high scenario), indicating economic viability at full risk adjusted capital costs;
  - robust at low demand scenario, indicating the viability of the project isn’t sensitive to unexpected swings in demand and take-up rates.
- Results are sensitive to decongestion benefits – i.e. if you assume suppressed demand results in no decongestion benefits or changes to the vehicle usage of other motorists, the projects lose economic viability.
- Even without any decongestion benefits, the projects would remain viable if the WHO methodology was used to estimate health benefits — assuming no decongestion benefits at all but using the WHO methodology, the BCR would be 2.0.

The importance of providing the major missing links

Providing multiple small budget transport projects in many cases provides high or higher returns and better value for money than some large projects. In addition, the impact on the community can be more significant than for large scale, high budget, transportation projects. This concept is called ‘small is beautiful’ and has been developed by the UK Department for Transport when developing the Eddington study\(^2\) (Figure 19).

While not reflecting the results of a randomly selected collection of projects, Figure 18 shows that schemes costing less than £1 billion (approximately $2.2 billion) provided higher wider BCR than schemes above £1 billion in the recent UK “Eddington study”.

The Eddington Study recommends adopting a balanced project portfolio that meets the range of policy goals (economic, environmental and social). The cost benefit analysis of the major missing cycle links demonstrate this ‘project portfolio’ is providing substantial benefits to the community estimated to be $125.2M.

Sydney regional cycling network is highly fragmented and providing these major missing links will be a better improvement than providing a large budget scale cycle ways which would not take into account user needs and current deficiencies of the network and would result in a lower BCR.

\(^2\) UK Department of Transport, 2006, The Eddington Transport Study [http://www.dft.gov.uk/about/strategy/transportstrategy/eddi]
Figure 19: Small is beautiful

![Small is beautiful chart]

Source: Eddington Transport Study, UK DfT

Figure 20 compares the Sydney regional major missing cycle ways BCR with other economic appraisal undertaken to assess the return of significant Australian road and rail infrastructure upgrades.

Figure 20: Selected CBA for comparison with the Sydney Metropolitan Cycle Network major missing links CBA ($millions)

<table>
<thead>
<tr>
<th></th>
<th>Sydney Metropolitan Cycle Network major missing links</th>
<th>East West Link needs analysis (Melbourne)</th>
<th>RTA Pacific Highway upgrade – Coopernook to Moorland corridor</th>
<th>Railway extension between Robina Station &amp; Elanora Station (QLD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td>92.2</td>
<td>15.0</td>
<td>20.2</td>
<td>303.0</td>
</tr>
<tr>
<td>Benefits</td>
<td>125.2</td>
<td>20.4</td>
<td>45.1</td>
<td>75.8</td>
</tr>
<tr>
<td>BCR</td>
<td>1.3</td>
<td>1.4</td>
<td>2.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>
4 Social value of cycling

If we are to fully understand the impact of cycling programs and projects on NSW communities, it is necessary to acknowledge the impact of such investments from a broader socio-economic perspective.

Alongside economic efficiency, the importance of ‘social capital’ is gaining increased attention in both theoretical and applied social science, and is particularly relevant to appraising transport options within our communities.

What is social capital?

Social capital refers to the connections within and between people’s social networks. The Organisation for Economic Cooperation and Development’s (OECD) and Australian Bureau of Statistics define social capital as ‘networks, together with shared norms, values and understandings that facilitate cooperation within or among groups’. Social capital essentially enables individuals to function cooperatively for mutual benefit.

The current literature conceptualises social capital as a resource, which along with physical or produced economic capital, environmental capital and human capital, can be drawn upon by individuals, groups and communities to achieve social and economic outcomes. ‘Social capital’ itself describes how economic agents interact with one another as they draw upon resources to achieve these outcomes.

The Productivity Commission has linked the presence of social capital with outcomes such as:

- positive mental and physical health outcomes;
- equality and welfare;
- better educational outcomes
- decreasing crime and violence; and
- governmental responsiveness and efficiency.

Other studies have also identified a decreased risk of social isolation, which has been linked directly with some of these outcomes, such as reduced risk of premature mortality, cardiovascular disease, and mental health problems.

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74 Productivity Commission, 2003; ‘Social Capital: Reviewing the Concept and Policy Implications, Research Paper’ Canberra, Australia
There is also a significant, and growing body of research regarding the contribution of social capital to economic development, and the creation of economic value in communities, such as through:

- reduced transaction costs;
- increased levels of innovation;
- community ‘substituting’ for government and markets;
- lower systems costs associated with reduced demand for government assistance; and
- the facilitation of higher levels of human capital productivity, especially skills development, workforce participation, increasing employment prospects and reducing labour precariousness.  

**Dimensions of social capital**

The ABS has articulated a ‘Framework for Social Capital’ to describe and measure aspects of social capital. The framework has been successfully adapted by the Bureau of Transport and Regional Economics (BTRE) and others to compare and assess the social capital value of different regions and projects. This framework is illustrated in Figure 21 and includes a range of network types, structures, transactions and qualities to reflect the multidimensional nature of the concept.

Infrastructure, facilities and space, are important resources for social capital, and social capital is generally understood to be spatially based, with many elements being dependent on geographic proximity. Whilst technological advances have reduced many barriers associated with spatial distance, face-to-face human interaction and identification with places remain key concepts in social capital generation.

Access to, and use of, transport within and around communities therefore has a key role to play in facilitating creation of social capital. The mechanism by which this can occur is through increasing mobility, enabling access to people and facilities, and encouraging interaction with others.

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76 Bureau of Transport and Regional Economics, 2005; ‘Focus on Regions, No.4 Social Capital, Information Paper 55’ Canberra, Australia.


78 Onyx, J. 2001; ‘Community renewal and social capital: Key note address from the Community Technology Centres conference, December 3, Bathurst NSW, Australia.'
Figure 21 - The Social Capital Framework

The existence of community facilities, together with services provided from these facilities provide a focal point for community activities and social interaction. The absence or inadequacy of these facilities can lead people apart or draw people together to lobby for these facilities and their associated services to be provided, or to assist in their provision.  

Transport, and modal choice also have impacts on social capital. For instance, high levels of automobile use have been associated with low levels of social capital.

The social capital value of cycling

The activity of cycling and the presence or absence of cycling infrastructure has its own particular impact on social capital.

The particular nature of bicycle travel, being amenable to a wide range of purposes – from commuting to work, to cycling for fitness – means that there are a number of different ways in which cycling can generate or sustain social capital, including:

- **Providing mobility to all** – In terms of both running costs and maintenance costs, cycling is one of the lowest cost transport options available, meaning that individuals from more socio economic groups, and more locations, can be upwardly mobile. By providing relatively equal access to all, bicycles reduce social exclusion and allow access to employment, education, housing and other social and community services.

- **Empowering children and aged persons** - Another important aspect of the mobility of bicycles is that it affords children and aged people a mode of transport and a sense of independence.

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81 The running cost of cycling is negligible when compared with the $183 per week estimated to be required to run the cheapest medium sized car in Australia – National Roads and Motorists’ Association (NRMA) Motoring + Services 2007, June 2007 ‘Private Whole of Life Vehicle Operating Costs Report: Ascending Costs Summary, 17 July 2007, Sydney, NRMA, p21.

82 The annual cost of maintaining a bicycle is estimated at around a quarter of that required to maintain a car – Sustrans, 2008, ‘Why cycle?’ available at: http://www.sustrans.org/webfiles/leaflets/sustrans_whycycle_March08.pdf

mobility has been found to greatly improve the socialisation of children\(^{84}\), and both children and their families who live in neighbourhoods not dominated by traffic, with more opportunities for cycling, and access to parks and play spaces, have wider sets of friends.\(^{85}\)

- **Improving access** – Bicycle travel allows users to access locations which are not serviced by public transport, or even not accessible by road. It also enables people to travel at their convenience, unrestricted by routes or timetables. Further, when linked with other public transport modes cycling can open up cities to those without access to a car.\(^{86}\)

- **Supporting community development** – People who cycle have been found to be more likely to access local goods and services, and support small businesses in their area.\(^{87}\) This increases the interaction between members of the same community and aids in the building of cohesive local networks.

- **Sport and recreation** – Bicycle users are able to engage in sport and recreational activity whilst fulfilling alternative trip purposes, with considerable health benefits.\(^{88}\) Bicycles also enable users to access community sporting facilities and sporting fields which are key hubs for social interaction between community members. Social and competitive team cycling expeditions are also contributors to the socialisation, health and wellbeing of participants.\(^{89}\)

- **Facilitating engagement with others and engagement with the community** – Cyclists are able to communicate with others whilst travelling, being able to sense the actions of all others around them and remain immersed in the streetscape environment. This kind of

---


travel – where individuals are not shielded from their surroundings - imparts a greater sense of connectedness with the community for both
the traveller and other people.\textsuperscript{90}

- **Opening up public spaces** – Because bicycle travel is possible without the need for socially disruptive infrastructure, such as roads, railway lines and bus terminals, cycling has negligible impacts on the social environment.\textsuperscript{91} In effect this can open up public spaces for more members of the community to enjoy, an important contributor to social capital.\textsuperscript{92}

- **Potential to improve land use decisions** – incorporating cycle ways into the built environment is likely to have a positive influence on the ability to access jobs, entertainment, schools, and other facilities by bike, improving the uptake and frequency of cycling trips and enhancing the social capital value of those trips.

**A framework for valuing the social capital of cycling**

The above impacts can be valued by developing a relevant set of social capital indicators for cycling, and comparing the social capital performance of cycling with other methods for achieving trip purpose.

This means assessing the social capital-producing outcomes of the commonly chosen modes of travel within Sydney Metropolitan communities, including\textsuperscript{93}:

- private vehicle;
- public transport;
- bicycle; and
- walking.

A series of appropriate social capital indicators were adapted from the ABS framework for this purpose, and are shown in the left column of Figure 22.

The elements selected are not intended to be a definitive set of measures for social capital outcomes attributable to cycling initiatives, but allow a high level qualitative analysis which compares and contrasts cycling with other

\textsuperscript{90} Project for Public Spaces, 2008, ‘About the PPS Transportation Program’, last viewed 15 January 2008 at http://www.pps.org/transportation/info/transportation_approach


\textsuperscript{92} ABS, 2004, op. cit.

transport choices available to members of Sydney metropolitan communities.

Each mode choice is assessed in terms of the extent to which it has a positive effect on social capital (i.e. a high, moderate, low or nil effect) according to the transport-relevant definition provided. Broader definitions for these terms nominated by the ABS are provided in Appendix C.

Analysis is limited to positive impacts because information obtained was not sufficient to enable a full analysis of both positive and adverse impacts. In this case, adverse or non-positive impacts are captured through a ‘no-impact’ rating.

Experts agree that social capital is organic in nature and can arise or fall over time depending on voluntary human actions and behaviours. Whilst social capital is viewed as the resource of a group rather than the property of any one individual, it can be accessed by individuals within the group. The method therefore assumes that social capital as a whole can be meaningfully measured by aggregating data collected from individual perceptions and actions.

This analysis considers direct impacts, and excludes indirect or secondary outcomes.

Results

Figure 22 below compares the social capital characteristics of each transport mode, which are rated as having a high, moderate, or low or no impact on generating social capital.

To derive these qualitative ratings, each transport mode was provided with a score out of 3 for their contribution to each social capital indicator, with 3 representing a high or strong impact, 2 indicating a moderate or medium impact, and 1 indicating a low or negligible impact.

Scores were then used to provide a qualitative impact assessment. In order to assess mode performance relative to cycling, ratios of the score were calculated (where cycling = 1) to achieve the values shown for ‘Relationship to cycling’ (Figure 23).

Thus, travelling by private vehicle has just over half the positive social outcomes of trips by bicycle. Public transport trips embody almost three quarters the positive outcomes, and trips by foot are marginally better than cycle journeys in terms of improving or promoting the attributes of various social capital indicators.
### Figure 22: Relative positive contribution of transport options to social capital

<table>
<thead>
<tr>
<th>Element</th>
<th>Relevant indicator</th>
<th>Travel by:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Private vehicle</td>
</tr>
<tr>
<td><strong>Network Qualities</strong></td>
<td></td>
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<tr>
<td>Trust</td>
<td>Feeling of safety when travelling at night.</td>
<td>●</td>
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<tr>
<td>Co-operation</td>
<td>Ability to engage with others whilst travelling or work as a group or team for mutual benefit</td>
<td>○</td>
</tr>
<tr>
<td>Acceptance of diversity and inclusiveness</td>
<td>Ability for disadvantaged and minority groups to access and use mode with ease.</td>
<td>○</td>
</tr>
<tr>
<td>Social participation</td>
<td>Ability for users to participate in sport or recreational physical activity.</td>
<td>○</td>
</tr>
<tr>
<td>Civic participation</td>
<td>Active membership of users to mode-relevant groups, teams, clubs and/or institutions.</td>
<td>○</td>
</tr>
<tr>
<td>Friendship</td>
<td>Travelling with others for leisure or recreation.</td>
<td>○</td>
</tr>
<tr>
<td>Economic participation</td>
<td>Likelihood of using mode to contribute to local business and local community economy.</td>
<td>○</td>
</tr>
<tr>
<td><strong>Network structure</strong></td>
<td></td>
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<tr>
<td>Size of network</td>
<td>Proportion of households able to access mode.</td>
<td>○</td>
</tr>
<tr>
<td>Network frequency / intensity and communication mode</td>
<td>Ability to communicate with other mode users and outsiders whilst travelling.</td>
<td>○</td>
</tr>
<tr>
<td>Transience / mobility</td>
<td>Distance or time required between desire or intention to travel and travelling.</td>
<td>●</td>
</tr>
<tr>
<td>Power relationships</td>
<td>Ability to travel without dominating or disturbing the streetscape and/or individuals not using the mode.</td>
<td>○</td>
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<tr>
<td><strong>Network transactions</strong></td>
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<tr>
<td>Physical/financial assistance/emotional support and encouragement</td>
<td>Ability to connect physically and/or emotionally with neighbours whilst travelling.</td>
<td>○</td>
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<tr>
<td>Integration into the community</td>
<td>Ease with which a newcomer can comfortably access the mode and travel accordingly.</td>
<td>○</td>
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<tr>
<td>Common action</td>
<td>User desire to improve quality or increase provision of facilities for mode use.</td>
<td>○</td>
</tr>
<tr>
<td>Sharing knowledge, information and introductions</td>
<td>Instances of teaching or learning or engaging in study or self-development while using mode.</td>
<td>○</td>
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<tr>
<td>Negotiation</td>
<td>Ability to avoid, reduce or resolve conflicts, anger or violence, or accidents occurring in a travelling context.</td>
<td>○</td>
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<tr>
<td><strong>Network types</strong></td>
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<tr>
<td>Isolation</td>
<td>Feeling of presence, connectedness and engagement with community and surroundings whilst travelling.</td>
<td>○</td>
</tr>
</tbody>
</table>

○ = no/negative impact on indicator attributes  
● = moderate / medium impact on indicator attributes  
● = high / strong impact on indicator attributes
Discussion of results

While in no way an exhaustive analysis, this qualitative analysis highlights the relative strengths of each transport mode, and provides insights as to the social capital outcomes of investment decisions.

Both cycling and walking rate moderate to high on most aspects of social capital. These forms of transport allow for more interactions and greater connection with the community. Their high ratings also reflect their strong linkages with sport, leisure and recreational activities, contributing to greater wellbeing of community members. They are also the most easily accessible forms of transport, allowing children and economically disadvantaged groups equal mobility.

Whilst public transport was thought to have a high social value on some elements, route and timetable restrictions limit the mobility afforded to users.

Private vehicles afford owners a high level of mobility and feelings of safety, however overall, the typology used suggests as a mode of transport they contribute little to the development of social capital. The main reasons for this include:

- inability to connect socially with outsiders whilst travelling;
- dominating nature of motor vehicles on community roads;
- higher risks and severity of accidents; and
- exclusion of children and less advantaged group from access.

Overall, the results suggest that the cycling mode is likely to deliver 1.7 times more social capital than private vehicles as a transport choice for community members.

Social capital value of missing link pathways

The missing link pathways represent an important opportunity to accelerate the creation of social capital through cycling in Sydney’s metropolitan areas.

By connecting existing cycle ways, and filling in the ‘missing links’, the pathways are providing access to more of the city’s cycleway network, enhancing the value of the existing facilities.

Each of the pathways proposed has a unique set of attributes, which are likely to deliver social capital in different ways, as outlined in Figure 24.
**Figure 24: Social capital attributes of each missing link cycleway**

L = has less than 5 social capital attributes  
M = has 5-10 social capital attributes  
H = has more than 10 social capital attributes

<table>
<thead>
<tr>
<th>Social capital attributes</th>
<th>Prospect to Blacktown</th>
<th>Moore Park</th>
<th>Naremburn to Harbour Bridge</th>
<th>Chatswood to Artarmon</th>
<th>Blacktown to Parramatta</th>
<th>North Ryde to Macquarie Uni</th>
<th>Botany Bay to Maroubra</th>
<th>Hunleys Point</th>
<th>M7 link package</th>
<th>Guildford to Chester Hill</th>
<th>Lidcombe to Strathfield</th>
<th>Cooks River to Lilyfield</th>
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</thead>
<tbody>
<tr>
<td>Provides a detour from on road travel.</td>
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<td>Provides access to community gathering places such as community centres and religious venues</td>
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<td>Provides cycle options to lower socio economic groups</td>
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<tr>
<td>Provides access to town centre or community business district</td>
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<tr>
<td>Creates the opportunity for fitness and exercise whilst commuting to major business districts</td>
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<td>Connects residential areas with education and training opportunities: Primary and secondary</td>
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<tr>
<td>Adjoins other sport or exercise facilities</td>
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<tr>
<td>Can be used for travel to/from community leisure and entertainment facilities</td>
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<td>Provides access to natural attractions, for example: Waterways, beaches or rivers National parks and reserves</td>
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<tr>
<td>Provides recreational opportunities for children such as parks or playgrounds</td>
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<tr>
<td>Connects residential areas with health and/or wellbeing facilities: Hospitals and major medical centres Aged care facilities</td>
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<td><strong>TOTAL RATING:</strong></td>
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</table>
In order to obtain the total ratings shown, 1 point was assigned to each attribute and summed. Out of a maximum of 14, cycle ways achieving 0-5 were given low ratings, 5-10 were given moderate ratings and over ten high ratings.

All proposed cycle ways were found to have a moderate or high number of social capital attributes.

Hence the proposed cycle ways generate a series of economic, social, and environment values. It is important that all of these factors are taken into account in making investment decisions. One tool for achieving this is Multi-criteria analysis (MCA). A skeletal MCA has been developed for future development to assist with this process, as shown in Appendix D.
Appendices

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Appendix C  Social capital definitions  62
Appendix D  Multicriteria analysis  64
## Appendix A

### Results of cost benefit analysis

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<tbody>
<tr>
<td>Total</td>
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<td>Benefits</td>
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<td>capital costs</td>
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<td>Savings in user cost</td>
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<td>Parking cost savings</td>
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<td>Travel time savings</td>
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<td>Bicycle crash costs</td>
<td>(0.41)</td>
<td>(0.47)</td>
<td>(0.54)</td>
<td>(0.57)</td>
<td>(0.58)</td>
<td>(0.59)</td>
<td>(0.60)</td>
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<td>Noise reduction</td>
<td>5.18</td>
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<tr>
<td>Infrastructure provision</td>
<td>23.86</td>
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<td>Greenhouse gas reduction</td>
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<td>Residual</td>
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<tr>
<td>Total Benefits</td>
<td>313.02</td>
<td>124.91</td>
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<tr>
<td>Incremental Benefits</td>
<td>211.45</td>
<td>89.84</td>
<td></td>
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</tbody>
</table>

### Key Metrics

- **BCR**: 1.3
- **NPV**: 29.84
- **NPVI**: 0.31
- **EIRR**: 9.7%
Appendix B  Demand forecast methodology

The number of cycle trips expected to use each missing link comprises a range of average daily total trips.

A range of average daily total trips has been developed.

1  The low end of the range is based on a combination of:
   a  knowledge of the existing usage of adjacent cycle ways (where available),
   b  2006 Census data for bicycle-only Journey to Work trips with a destination in each missing link’s surrounding LGA and
   c  discounting of medium-high trip numbers (see below).

2  The medium-high point on the range is provided by applying an aspirational percentage to the number of daily <10 km car trips accessing, or occurring in the catchment of, the nearest Metro Strategy centre, as known from NSW Transport Data Centre Household Travel Survey data for 2006. This number is added to the number of existing daily users where known. For those corridors where existing RTA permanent counters (on the Sydney Harbour Bridge and Anzac Bridge) provide reliable real time numbers of bikes, the total demand estimate has been compared – and found to be broadly consistent – with existing usage and growth trends. The detailed methodology behind this approach is described below.

3  The chosen percentage of 2.5% of <5 km car trips by bike is based on Parsons Brinkerhoff (PB) report findings (PB 2008), which refer to 2006 commuting mode share outcomes in Victoria, Queensland, SA and WA. Using an average of cycling use for the Journey to Work in these states, PB suggests a mode share objective of around 1.5% of commuting trips by bike in all of NSW in 2016, or a near doubling of the 2006 percentage.

4  For this to be achieved would require NSW as a whole to obtain the 7% annual growth rate in the share of commuter trips by bike that was seen in Melbourne between the 2001 and 2006 Censuses. This would necessitate particularly high growth in cycling to those centres serviced by the Sydney Metro Strategic Cycle Network, given the much slower growth obtainable in other parts of the State where longer commute trips are the norm and attractive cycling infrastructure will continue to be harder to provide for such longer trips.

5  For the Metro Strategy centres which need to see a high proportion of additional bike trips for a state-wide growth objective to be reached, it could be appropriate to aim for the cycling mode share that was achieved in south-eastern Australia’s most successful commuter cycling destination LGA as measured in the 2006 Census: the City of Melbourne LGA, with 2.5% of trips by bike.
6 This commuter cycling benchmark could stand as the bike mode share objective for short trips (<5 km) of all purposes with a destination in a Metro Strategy centre. For medium-length trips (5-10 km) of all purposes to a centre, the objective could be reduced to 0.5%, based on HTS findings regarding the lower proportion of trips of this duration currently being undertaken by existing Sydney cyclists.

7 Additionally, there could be a bike mode share objective for dispersed trips of all purposes, which occur within each Metro Strategy centre’s ‘catchment’ while not having a destination in the centre itself. For short trips this could be a state-wide Journey to Work mode share objective of 1.5% of trips; for medium-length trips, up to 10 km, it could be 0.5%. The base to which these percentages are applied could be calculated by giving each centre catchment a nominal share of Sydney-wide dispersed trips that is equivalent to that centre’s ‘density of centre-based travel activity’ relative to other centres.

8 Taking the number of wholly new cycle trips to (and within the catchment of) each relevant centre, calculated as described above, one could then estimate the daily usage of each missing link has been estimated by:

   a  (for trips to centres only, not dispersed trips) doubling the one-way total to allow for return trips and

   b  discounting the two-way total by up to 90% per relevant centre catchment, to allow for directionality – e.g. Prospect – Blacktown effectively services only the southern quadrant of Blacktown’s catchment.

9 The total number of trips calculated through the process described above represents medium to high expectations for the average daily total of new (i.e. ex-car) bicycle trips using each missing link at its busiest point, were it in place as part of a complete network in the base year of 2006.

---

Figure 24: Total expected demand by 2016

<table>
<thead>
<tr>
<th>Demand scenario</th>
<th>Daily trips</th>
<th>Diverted km from car trips</th>
<th>Diverted km from non car trips</th>
<th>Total km diverted</th>
<th>Total bicycle km (including new cycling trips)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 5 km</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Average daily km</td>
<td>Average daily km</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>10030</td>
<td>45,540</td>
<td>65,337</td>
<td>23,848,063</td>
<td>25,040,466</td>
</tr>
<tr>
<td></td>
<td>5 – 10 km</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>11595</td>
<td>53,722.50</td>
<td>77,077</td>
<td>28,133,016</td>
<td>29,539,667</td>
</tr>
<tr>
<td></td>
<td>2525</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>13160</td>
<td>61,905</td>
<td>88,816</td>
<td>32,417,970</td>
<td>34,038,868</td>
</tr>
<tr>
<td></td>
<td>2990</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes – Assumes average trip length for journeys <5km is 3km and for journeys 5km – 10km is 7.5km. Car mode share is 69.7% of total Sydney journeys (TDC 2002). Assumed induced cycling for recreational cycling, only used in the calculation of health benefits is 5% of total cyclists.
Appendix C  Social capital definitions

- **Trust** – Confidence in the reliability of a person or system to act or perform as promised, promoting confidence and effective functioning of society, minimising the need for bureaucracy and rules.
- **Cooperation** – Shared or complimentary action or sense of purpose to achieve goals.
- **Acceptance of Diversity and inclusiveness** – Attitudes and behaviours that display respect, understanding and appreciation of diversity in relation to race, gender, ethnicity, intellect, etc and recognition in regard to differing needs, abilities and aspirations of people.
- **Social participation** – Participation in enjoyed activities, involving the interaction with others in either formal or informal settings.
- **Civic participation** – Involvement and engagement in matters relating to governance and democracy; a two way communication process between community and governments; the involvement of citizens in government decision making.
- **Friendship** – The relationship between persons well known to each other characterised by feelings of mutual affection and loyalty.
- **Economic participation** – Social networks or relationships through which people engage in activities of an economic nature.
- **Size of network** – The number and variety of relationships or contacts individuals or groups may have.
- **Network frequency/intensity and communication mode** – Frequency of contact between individuals or groups within social networks and the methods and modes of communication.
- **Transience/Mobility** – The capacity to move in and out of situations within relatively short periods of time. Movement is represented by population growth and retention.
- **Power relationships** – The relative positions of power between individuals within or between groups, and between individuals and organisations. Power relationships include leadership and mentoring.
- **Physical/financial assistance/emotional support and encouragement**
- **Integration into the community** – The acceptance and inclusiveness of a community, including the capacity to welcome newcomers/new network members; the capacity of a community to provide adequate services and facilities that enable newcomers/those outside the networks to communicate and integrate into the community.
- **Common action** – Collective action to achieve an outcome with a specific focus on the initial action or getting things under way which may turn into a longer term activity.
- **Sharing knowledge, information and introductions** – The formal and informal exchange and sharing of information and skills between individuals and members of a community or group.

- **Negotiation** – Approaches to conflict resolution of the achievement of mutually satisfactory outcomes.
Appendix D  Multicriteria analysis

This report has highlighted a range of quantitative and qualitative attributes of cycle ways, and made a series of observations about the economic, social, and environment value of investing in cycling infrastructure.

However, compared to other transport investments, cycling investments arguably have more intangible and/or unquantifiable values, which make investment decisions more complex.

For instance, some transport investment decisions are able to draw upon clearly identified travel time savings that can be transposed into productivity enhancements and by counting the number of uses, can be valued in economic terms. Other transport investments in black spot road programs for instance can look at reductions in serious accidents that can be valued using contingent valuation techniques to derive a value of life in economic terms to justify their approval.

The benefits of cycle ways can be less obvious, particularly when they include option value rather than actual use values, and aesthetic values rather than shorter trip times.

This section of the report brings the insights from this analysis into a Multi-Criteria Analysis framework (MCA) to assist policy makers assess the total value of cycle ways, including those impacts that can be monetised and those that can not.

Principles of Multi-Criteria Analysis

Multi-Criteria Analysis is a decision-making tool developed for complex multi-criteria problems that include qualitative and/or quantitative aspects of the problem in the decision-making process.

Multi-criteria analysis (MCA) is a specific form of cost–benefit analysis that brings a degree of structure, analysis and openness to decision-making. It is particularly useful in circumstances where it is necessary to consider a range of economic, environmental and social costs and benefits which cannot be satisfactorily quantified and/or valued. MCA does allow, however, the inclusion of monetary valuations where available alongside other quantitative and qualitative valuations.

MCA establishes preferences between options by reference to an explicit set of objectives and measurable criteria to assess the extent to which the objectives have been achieved. In simple circumstances, the process of identifying objectives and criteria may alone provide enough information for decision-makers. However, where a level of detail is required MCA offers a number of ways of aggregating the data on individual criteria to provide indicators of the overall performance of options.

MCA is both an approach and a set of techniques, with the goal of providing an overall ordering of options, from the most preferred to the least preferred option. As a set of techniques, MCA provides different ways of:
disaggregating a complex problem into more manageable pieces to allow data and judgements to be brought to bear on the pieces;

- measuring the extent to which options achieve objectives against selected criteria;
- weighting the criteria (if desired); and
- re-assembling the pieces to present a coherent overall picture to decision-makers.

MCA is a staged approach (see Figure 25).

**Figure 25: Key steps in multi-criteria analysis**

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 4</th>
<th>Step 5</th>
<th>Step 6</th>
<th>Step 7</th>
<th>Step 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define the objectives for the options and establish the aims and context for the MCA</td>
<td>Identify the options</td>
<td>Identify the criteria for assessing the consequences (costs and benefits) of each option</td>
<td>Scoring: assess the expected performance of each option against the criteria</td>
<td>Weighting: assign weights (if desired) for each of the criterion to reflect their relative importance to the decision</td>
<td>Combine the scores for each option to derive an overall value</td>
<td>Examine the results</td>
<td>Conduct sensitivity analysis</td>
</tr>
</tbody>
</table>

MCA is useful because it requires a clear enunciation of the criteria by which the proposals are being judged. They must reflect the absolute and/or relative performance of the options, and must be measurable, in the sense that it must be possible to assess, at least in a qualitative sense, how well a particular option is expected to perform in relation to the criteria.

A ‘top-down’ approach seeks to identify the overall objectives that are to be achieved; a ‘bottom-up’ approach aims to identify how the options differ from one another in ways that matter (both benefits and costs).

The scores (weighted or unweighted) for each option are aggregated to derive an overall value. The results are presented in a performance matrix, in which each row describes a criteria and each column describes the performance of the options against each criterion.

The ranking approach which is development for cycling infrastructure is shown in Figure 26 below, which require the identification of the policy principle, the development of criteria that are required to meet those objectives, and the rating of indicators to show the extent to which those criteria are met.
Scores for each criterion can range from -1 to 1 depending on the likely impact of the investment or change; -1 symbolises the most negative impact whilst 1 represents the most positive impact. Each of the difference alternatives can be given scores according to rank based on the relationship to the base case. Scores are typically based on consultation with relevant stakeholders. Scores between 0.5 and 1 represent the most significant impact whilst scores between 0.0 and 0.5 represent a mild impact when compared with the base case. This scale is the same for negative impacts.

MCA of cycling infrastructure

Next steps

To conduct an MCA of investing in the missing link cycle ways, it is important for stakeholders to clearly identify what the key objectives of the investment are, and what the alternatives are, as these elements will form the structural foundations of the approach.

The most important and most relevant factors should be selected from the wide range of economic, social and environmental costs and benefits relevant to cycling.

Sample objectives have been developed based on discussion of these factors earlier in this report, and are listed in the leftmost column of the example MCA in Figure 27. However, these should be reconsidered and reset in accordance with the priorities of relevant stakeholder groups.

Alternative options for achieving the objectives are listed horizontally across the top of the table. In the example MCA below, we have listed only two options, the ‘Base case’ current situation, and the proposed investment in the missing link cycle ways. In some cases, other options for achieving the objectives may need to be considered.

The relative importance of each objective should be captured by an appropriate weighting, depicted in Column 2. In the below example, each of the objectives have been assigned an equal weighting for simplicity, however in reality, some objectives are likely to be more important or relevant than others and will be assigned higher or lower weights.

Once these elements of the MCA have been set, stakeholders can proceed with scoring the impacts of the alternatives against each objective.
For illustrative purposes only, we have undertaken a preliminary rating of the proposed cycle ways in terms of their contribution to certain objectives.

**Figure 27 - Example MCA of cycling infrastructure**

<table>
<thead>
<tr>
<th>Objective</th>
<th>Weighting</th>
<th>Base case (current policy &amp; infrastructure)</th>
<th>Investment in missing link cycle ways</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reducing congestion on major arterial roads</td>
<td>17%</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Promoting active lifestyles and health benefits</td>
<td>17%</td>
<td>0.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Providing additional safety assurance to cyclists and potential cyclists</td>
<td>17%</td>
<td>0.2</td>
<td>0.8</td>
</tr>
<tr>
<td>Reducing pollution and greenhouse gas emissions</td>
<td>17%</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Increasing the liveability of Sydney metropolitan communities</td>
<td>17%</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Minimising costs to government</td>
<td>17%</td>
<td>0</td>
<td>-0.3</td>
</tr>
<tr>
<td><strong>Total Score</strong></td>
<td><strong>100%</strong></td>
<td><strong>0.13</strong></td>
<td><strong>0.28</strong></td>
</tr>
</tbody>
</table>

The relative impact for each option is multiplied by the weight for each criterion. This step is not shown above because identical weightings have been assigned to each of the objectives. These are then added together to produce an overall quantitative impact for each alternative option.

The benefits of using the MCA framework for cycling are the ability to capture the many intangible benefits of cycling. With both quantitative and qualitative factors captured, the resulting scores for each alternative can be assessed and compared.

The above example shows that under the parameters set, investment in cycle ways appear to be preferable to the base case option.

The fact that a very different result could have been achieved if different objectives or weights had been assigned highlights the importance of the initial steps in the MCA.

Future iterations of this methodology could consider aligning the objectives of the MCA to the targets set out in the State Plan for NSW.
Exclusions

MCAs allow for a limited number of objectives to capture the key factors relevant to a decision. Therefore, a number of factors discussed in this report will necessarily be excluded from the MCA. Whilst still relevant to the issue, the MCA should deliberately exclude those impacts that are not material to the investment decision.

By way of example, in our initial assessment we have excluded a range of impacts, including:

- roadway cost savings;
- parking cost savings;
- reduced noise pollution;
- reduced/increased travel time; and
- savings in user cost.


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