Appendix 1 Bike Infrastructure Typologies and Data Analysis

Developed for the Kingborough Cycling Strategy

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Kingborough

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Contents

List of figures

List of tables

1. Infrastructure typologies

The purpose of this section is to provide an overview of different types of bicycle infrastructure, design principles and general guidance on factors to consider when selecting the infrastructure type.

1.1 Design principles

The design principles for each infrastructure type provide an overview of good practise design for developing cycling infrastructure and cyclable environments. These principles are drawn from practitioners' guides, including the *Cycleway Design Toolbox* by Transport for NSW, and provide guideline information for decision makers and designers.

1.2 On-road – mixed traffic

1.2.1 Sealed Shoulders

Sealed shoulders are demarcated road space, on the edge of travel lanes, which cyclists may use, but are not dedicated cycling infrastructure. They may be suitable for cycling when at least 1.5m wide with a maximum 10mm aggregate seal. Where space is limited, and only one sealed shoulder is possible, this should be uphill, to allow slow moving cyclists more space.

On rural roads with posted speeds above 50km/h, wide sealed shoulders offer some safety benefit by allowing cyclists to ride out of the traffic flow. In built up areas, sealed shoulders are not appropriate, as parked cars limit the ability of cyclists to use these shoulders. Figure 1 provides an example of a sealed road shoulder, with rumble strips to warn drifting motorists to keep within the travel lane.

Figure 1 Sealed road shoulder

1.2.2 Sharrows

Sharrows are bicycle stencils painted onto the road surface, with two chevrons above. They are intended to indicate to motorists that the expectation is that motorists share the space with people on bikes. Sharrows are not dedicated bicycle infrastructure, but are useful in certain circumstances where space is not available for dedicated infrastructure and traffic volumes and speeds are low. Additionally, sharrows can be useful for wayfinding. Figure 2 shows an example of sharrows on a quiet residential street.

Figure 2 Sharrows
http://cyclingchristchurch.co.nz/2014/06/13/adelaide-sharrows/

1.2.3 Slow streets

Slow streets are shared environments in which all road users are encouraged to negotiate. In general, it is the intention that motorists use the street as a *'guest'* with walking and cycling having priority.

Slow streets have become popular in response to the COVID-19 pandemic as a way of providing active transport options with safe physical distancing. They provide a low-cost method of increasing actual and perceived safety. Slow street treatments involve reducing speed limits to 30km/h or less and installing signage indicating that motorist are to provide priority to active modes.

Slow streets are not a recommended treatment for through traffic streets, and they should be reserved for cul-de-sacs and other very low volume streets. In the *Kingborough Cycling Strategy*, slow streets have been recommended for cul-de-sacs and other non-through streets which connect to the existing off-road walking network, enhancing safety and active transport permeability. They have the additional benefit of allowing streets to become part of the public realm for non-transport activity such as sports play (e.g., street cricket) and socialisation. Figure 3 shows the signage appropriate for indicating a slow street and its connectivity to other parts of the cycling network.

Figure 3 Slow street signage

Figure 4 provides an illustration of the sign used in the Netherlands to indicate a shared space environment, which is used on quiet residential streets with very low traffic volumes.

Figure 4 A 'living street' sign, The Netherlands

1.2.3.1 Slow streets design principles

- Slow streets should have a speed limit not exceeding 30km/h.
- Slow streets should have 'watch for cyclists' signs installed at road thresholds.
- Slow streets should have children crossing, or similar, signs installed at road thresholds.
- Slow streets should have 'slow' signs installed at regular intervals of at least every 100 metres.

1.2.4 On-road – painted lane

On-road bike lanes are at least 1.5m wide with a white painted line separating motor vehicles from cyclists, and bicycle logos and bike lane signage. They provide a low level of separation between riders and motor vehicles. Motor vehicles are prohibited from parking in bike lanes. Painted lanes are most suitable for streets with low traffic volumes and speeds below 50km/h. Figure 5 shows a painted bike lane between parking bays and travel lane, which should be avoided where possible, due to the risk of car dooring.

Figure 5 Painted bike lane

1.2.4.1 Painted lane with buffer

Painted buffers can provide a higher degree of separation from motor vehicles. Buffers can be on either or both sides of the painted lane, depending on context. Where kerbside parking is permitted to the left of a painted lane, buffers can provide space so cyclists may ride to the right of the 'door zone'. Where speeds or traffic flows are higher, buffers between motor vehicle lanes and painted lanes can provide greater space, increasing actual and perceived safety. Figure 6 shows a buffered bike lane, providing safe space between the car door zone and bike lane.

Figure 6 Buffered bike lane

Source: Philip Mallis (Flickr)

1.2.4.2 On-road bicycle lane design principles

- Speed limits on roads with on-road, painted bicycle lanes should generally not exceed 50km/h.
- On-road bicycle lanes should be 1.5 metres wide, on both sides of the street.
- Where space is insufficient, lanes below 1.5 metres can be acceptable. Narrow lanes still permit safer outcomes than no bicycle lane.
- Parking should not be permitted adjacent to bicycle lanes below 1.5 metres in width, due to the risk of car dooring.
- Where space is insufficient for on-road cycle lanes on both sides of the road, they should be placed on the uphill sections.
- Where space is insufficient for on-road cycle lanes in either direction, but cycling is desired, shared paths should be considered.
- Where space is insufficient for on-road cycle lanes in either direction and shared paths are unfeasible, but cycling is desired, the introduction of design features to lower vehicle speeds should be considered. These include:
  - Lowered speed limits or advisory speeds to 40km/h, especially through corners
  - Install 'watch for cyclist', or similar, signs
  - Narrowed general traffic lane width (3 metres or below) with more space on shoulders
  - Paint 'dragon teeth' or 'zig zag' road markings
  - Rumble strips on outer lane markings.

Intersection design principles

- At signalised intersections, on road cycle lanes should have bike boxes.
- At signalised intersections, advanced start bike lanterns should be installed.

Green painted surface delineating space for cyclists should be applied through intersections and for 10 metres either side.

1.3 On-road – protected

Protected on-road bike lanes are built within the road carriageway, with a physical barrier separating cycling lanes and motor vehicles lanes (either parking or traffic). These lanes are placed kerbside and should be at least 1.5m wide, with 1.8m to 2m preferable, to allow for overtaking. However, narrower protected lanes are still preferable to no physically separated lanes at all. Where parking is provided, the separator should be a minimum of 300mm to provide a buffer for car doors. Physical separation can be either '*light*', with precast plastic adhered to the road surface, or heavy, with large blocks of concrete or stone embedded into the road.

1.3.1 One way pairs

In a single direction configuration, physically separated lanes are generally positioned on both sides of the road to accommodate travel in both directions. They are placed on the same side of the road as motor vehicle traffic. They are safer at non-signalised intersections than bi-directional cycleways (see Section 1.3.2), as drivers are more likely to anticipate the direction of travel, but they require slightly more road carriageway space. Figure 7 shows an example from Frome Street, Adelaide.

Figure 7 Separated single-direction lane

1.3.2 Bi-directional

Bi-directional bike lanes are more space-efficient than one-way pairs but intersection treatments need careful consideration (and are preferably signalised), due to the risk of drivers not looking for riders coming in the opposite direction. Figure 8 shows an example from Sydney.

Figure 8 Bidirectional lane, Sydney

Source: SydneyCycleways

1.3.3 Protected bicycle lane design principles

- Protected lanes should be a minimum of 1.5 metres wide, although lane widths of 1.8 metres are desirable.
- Protected bicycle lanes need to use a form of 'vertical separation' (such as bollards or garden boxes) of at least 100mm wide without parking or at least 300mm wide where parking is adjacent (to act as a buffer between open car doors and oncoming cyclists).
- Protected bicycle lanes on both sides of the road, in the same direction as traffic, is the preferred option (known as one way pairs).
- Where space is insufficient for separated lanes in both directions, bi-directional lanes on one side should be installed. Bi-directional lanes should be at least 2.5 metres. Signage and visual cues for motorists emerging from cross streets must be included to remind the motorist of the presence of cyclists travelling in both directions.
- Where possible, bi-directional protected bicycle lanes should not be adjacent to parking bays, to improve cyclist's sight lines and visibility for motorists.

Intersection design principles

- Green painted surface delineating space for cyclists should be applied through intersections.
- At signalised intersections, advanced start bike lanterns should be installed.

- At signalised intersections, left turns should have delayed start (e.g., red lights which turn off later in the cycle)

At signalised intersections with bi-directional lanes, all turns from lanes parallel to the bi-directional lane should be fully controlled.

1.4 Off-road – dedicated cycleway

Dedicated cycleways can be installed behind the kerb to provide a protected, off-road cycling path. These are suitable in situations where there is insufficient space within the road carriageway to install a bike lane without moving kerbs. The footpath remains separate and is located adjacent to property boundaries, with a separator (such as plantings or grassed strip) between the two. They offer a higher level of physical separation and safety. Dedicated cycleways can be either one-way pairs or bidirectional. Figure 9 is another Sydney example, noting the kerb and drainage difference from the previous Figure 8.

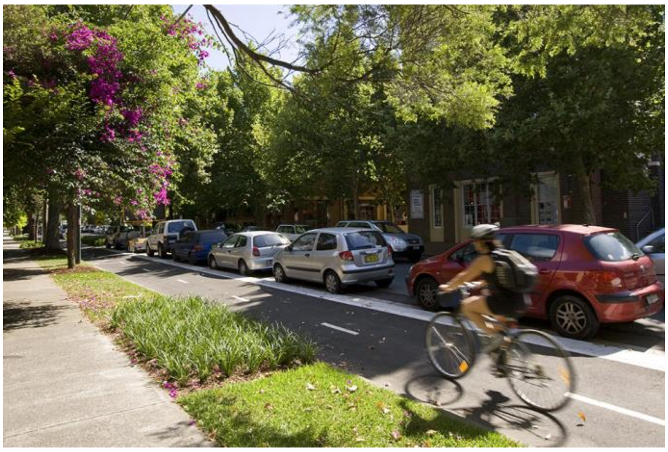

Figure 9 Bidirectional cycle lane (Bourke Street, Sydney)

Source: SydneyCycleways

1.5 Off-road – shared path

Shared paths are dedicated off-road infrastructure for pedestrians and cyclists. Cyclists are not the dominant mode, and are expected to share the space with pedestrians. Shared paths should be a minimum of 2.5m, ideally 3m in width. They can be sealed with bitumen, concreted, or made of compacted gravel. In all cases, they should be smooth and without tripping hazards and provide easy access for wheeled vehicles (e.g., bikes, mobility aids, shopping jeeps, etc).

There are a large number of walking paths within Kingborough which are potentially very useful for people on bikes and should be reviewed for upgrades for cyclists. In some cases, walking paths have steps or stairs. In order to accommodate bikes, troughing should be installed on one side of the steps, allowing bikes to be wheeled up or down. Figure 10 is an example from Kingston.

Figure 10 Shared path in Kingston

1.5.1 Shared path design principles

- Shared paths should be a minimum of 2.5 metres wide. Where use of the shared path by pedestrians and cyclists is higher, a width of 3 metres is desired.
- Shared paths should go on the side of the road that permits the desired width.
- If both sides permit the desired width, shared paths should go on the side which connects to the greatest number of other cycling or cyclable routes.
- Shared paths, where possible, should avoid running out the front of shops, to minimise conflict with other users.

- Shared paths, where possible, should run to the front of schools.
- Shared paths, were possible, should go on the side of the road which has the least driveways.
- Shared paths should avoid crossing from one side of the road to the other.
- Shared paths should avoid bollards and fenced barriers, as these pose a safety hazard.

1.6 Crossings

Dedicated cycling infrastructure often intersects with other parts of the road network, from local streets to large highways. There are several ways to accommodate cycling safely across the intersection, depending on the relative importance of the intersecting road and the desired level of safety for cyclists.

1.6.1 Refuge islands

Refuge islands provide a central waiting area in the middle of a road. The islands are often constructed out of concrete, providing protection from vehicle lanes. Refuge islands may be used where the cycleway intersects with a major road but where signalised crossing is not desired, due to low cycling and / or traffic volumes. Figure 11 provides an example of a refuge island, with pram ramps on each side leading back to the footpath.

Figure 11 Refuge Island

1.6.2 Continuous footpaths

Continuous footpaths are a design that maintains the footpath height and material across a side street. It maintains priority for pedestrians and bike riders. This type of intersection is ideally used where a footpath or protected cycle lane intersects with a local or residential street. Figure 12 shows an example that includes continuous footpath and separate cycle lanes.

Figure 12 Continuous footpaths

1.6.3 Wombat crossings

Wombat crossings, also known as raised zebra crossings, provide a safe mid-block crossing over a local, or collector road. They are appropriate where traffic speed is 50km/h or less and is located on a local or collector road, or is located within an activity centre. Wombat crossings can be used to provide safe crossings at roundabouts and other unsignalised intersections. Figure 13 shows a wombat crossing in Melbourne.

Figure 13 Wombat crossing

1.6.4 Signalised crossings

Signalised crossings use traffic lights to manage traffic movements and safe pedestrian and bike rider crossings. They are most appropriate where traffic speeds and / or traffic volumes are too high to safely install a wombat crossing, or the area where crossing is desired is too complex or dangerous. Signalised crossings can provide separate pedestrian and cycling waiting zones, as shown in Figure 14.

Figure 14 Signalised pedestrian crossing

Source: nzta.govt.nz

2. Data analysis

2.1 Study area and population density

Figure 15 shows a zoomed-in view of the major population and employment areas in Kingborough. The new residential estates are also shown in the south-western edge of the built-up area.

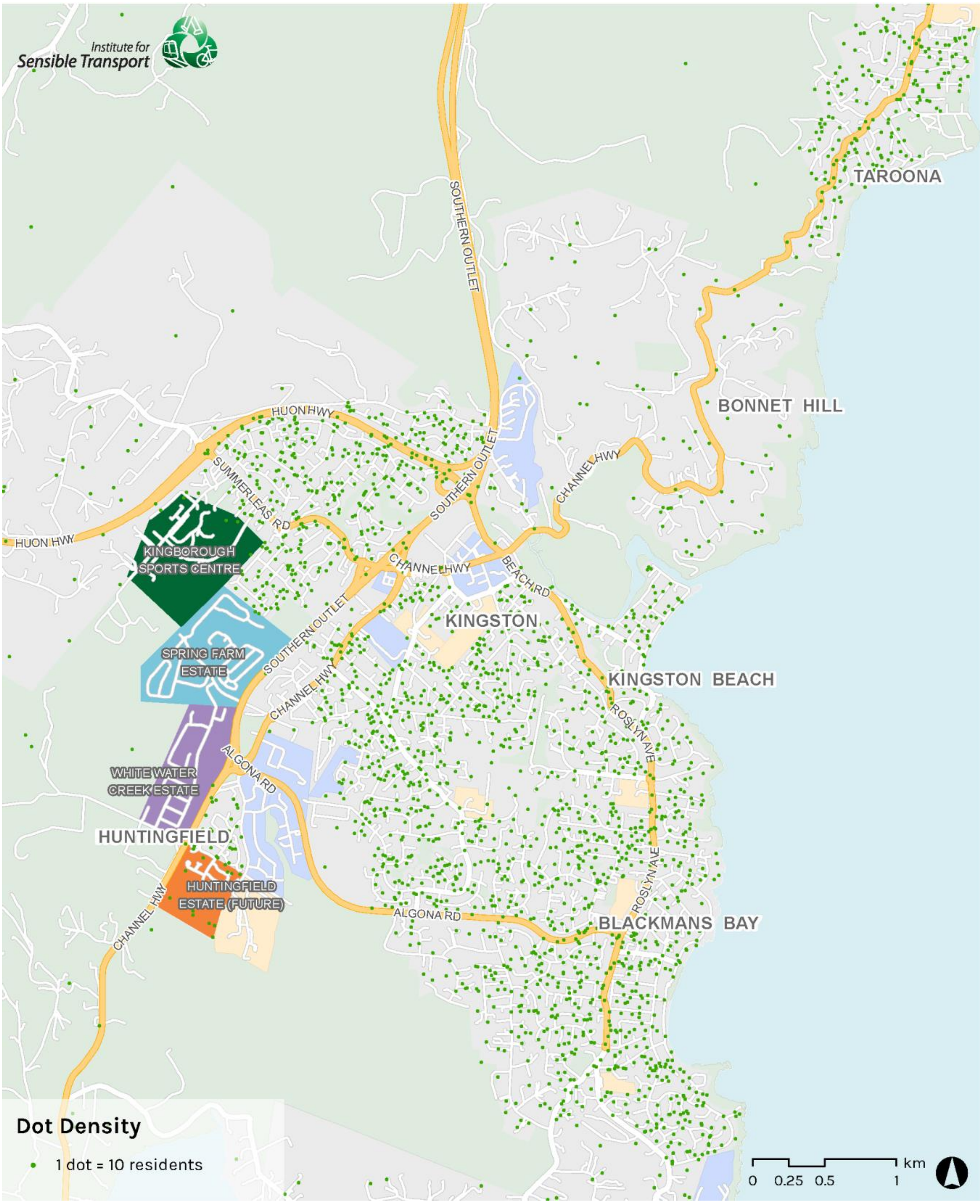

Figure 15 Study area - Built up area

2.2 Land use

Kingborough has a land use structure similar to other parts of Australia. It has a retail and civic CBD area with dispersed, low rise housing residential areas. Several light industrial and commercial precincts exist, separate again from the retail and civic area. For the next 10 years the growth priority areas for Kingborough are Spring Farm, Whitewater Park, Huntingfield and Kingston CBD.

Figure 16 Population density – Built up area

2.3 Journey to work

The *Journey to work* is the most comprehensive dataset of travel movements in Australia, as it is the only transport question included in the Census. We have examined journey to work data collected from the Census to better understand existing travel patterns and the potential for transferring short car trips to cycling.

Our team have interrogated the data available for Kingborough to produce the two graphs shown in Figure 17. The graph on the left is for all work trips (of any distance). It shows that almost 90% of all residents of Kingborough who travel to work do so in a motor vehicle. The most pertinent finding for the Cycling Strategy is that 86% of Kingborough residents drive even when the trip is 5km or less.

One-third of people who live in Kingborough work in Kingborough, while almost half of Kingborough residents work in Hobart.

For people that work in Kingborough, almost two-thirds of them also live in Kingborough.

Approximately 20% of trips to work to Kingborough are 3km or less. About one-third of commutes are 5km or less.

According to the Census, 9 in 10 Kingborough residents travel to work by car, and for trips 5km or less, 86% drive.

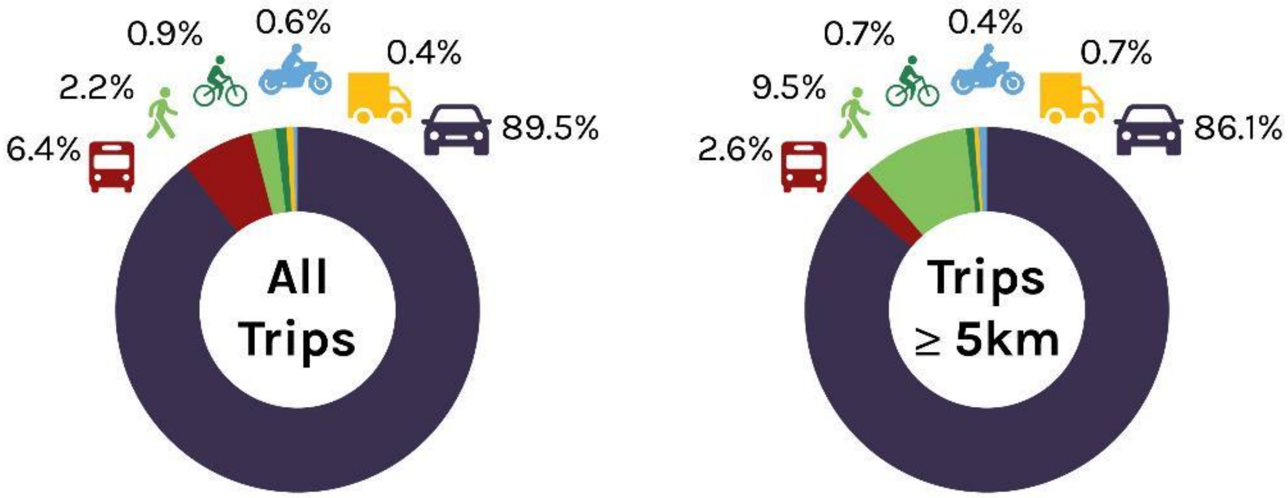

Figure 17 Journey to work for Kingborough residents

Source: ABS Census

2.5 Travel diary

Travel survey data for Kingborough is available via the *2019 Greater Hobert Household Survey of Travel*. Using sample surveys, travel profiles can be constructed for all Councils within Greater Hobart. It provides details regarding mode share for different trip purposes, movement between different Council areas, and how people move throughout the day.

2.5.1 Trips per day

Figure 18 shows the total number of trips taken per day in Kingborough. It shows an average of 3.5 trips per person per day. Kingborough residents spend approximately 1 hour a day travelling, covering 31 km.

Figure 18 Trips per day, Kingborough

Source: Department of State Growth (2019)

2.5.2 Trip Purpose

Figure 19 shows the breakdown in trip purposes for residents of Kingborough. Approximately 20% of all trips are work-related. Education trips constitute 10%, shopping 16%, personal business 8%, pick-up/drop-off 14%, social/recreation 21%, and 10% for other trip purposes.

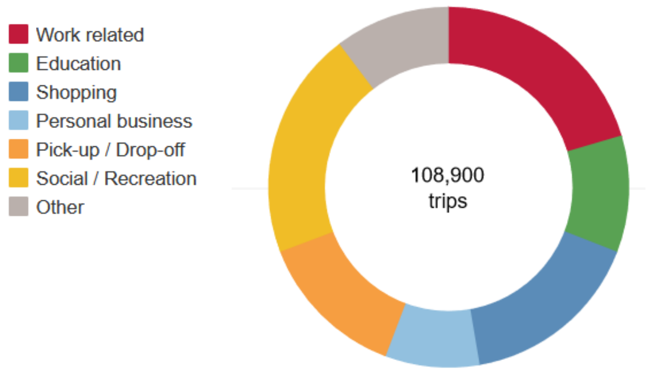

Figure 19 Trip Purpose, Kingborough

Source: Department of State Growth (2019)

This highlights the importance of better understanding non-work travel patterns and behaviour, as they constitute most trips on the transport system.

2.5.3 Mode Share

Figure 20 shows the breakdown in mode share for all trip purposes in Kingborough. Private cars make up most trips and kilometres travelled, however active transport (walking and bike riding) constitute 16% of all trips.

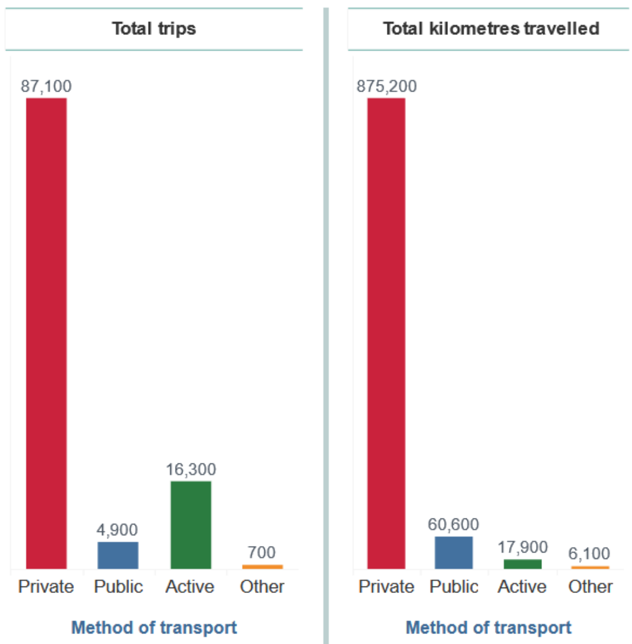

Figure 20 Mode Share for all trips, Kingborough

Source: Department of State Growth (2019)

2.5.4 Destinations

Figure 21 shows the destinations for trips that originated in Kingborough. The vast majority of trips that start in Kingborough also finish in Kingborough, for all times of the day. One-third of AM trips end in Hobart and 20% in the PM. Only a small proportion of trips finish in other Council areas.

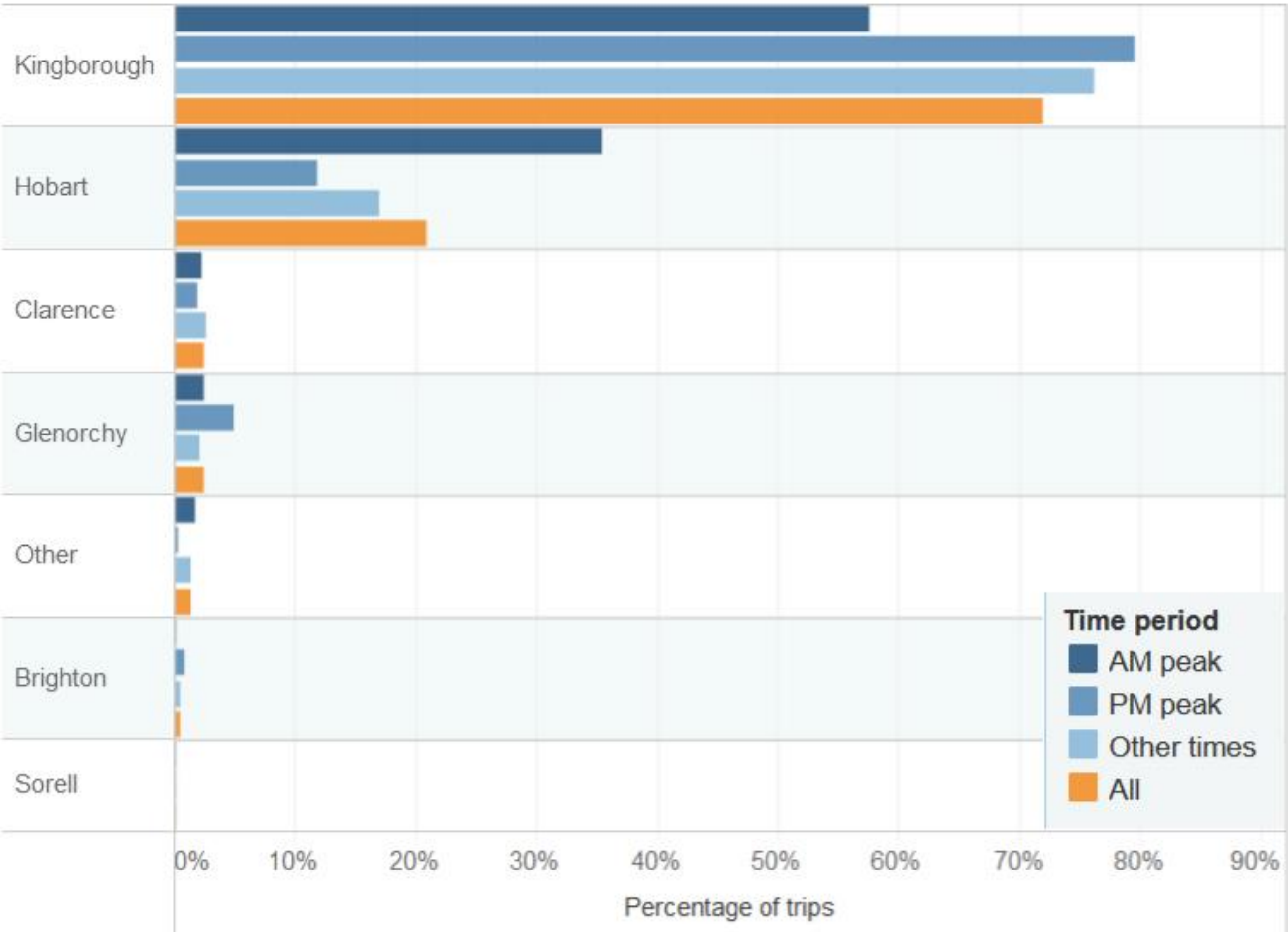

Figure 21 Destinations of trips starting in Kingborough

Source: Department of State Growth (2019)

2.6 Crash statistics

Table 1 shows the location and severity of crashes within the broader Kingston area between 2016 – 2020.

Broader Kingston Area

There were a total of 1,005 crashes recorded during the five-year period, including two fatalities, 21 serious injuries (requiring hospital admission), and 219 'other' or minor injury crashes (see Figure 25).

Excluding property damage and unknown crashes there is a downwards trend of injuries in the last five years (see Figure 22).

Crashes resulting in property damage totalled 763. Crashes were concentrated along the main arterial roads and highways and within the Kingston CBD area.

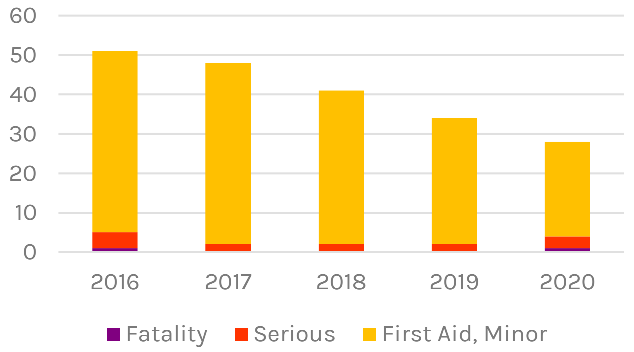

Figure 22 Crash injuries within Broader Kingston in the last five years

Cycling Crashes

Figure 23 identifies the police reported crashes involving cyclists that have taken place in the past five years, that were reported to police. This included four serious injuries and 26 'other' or minor injury crashes. No fatalities were recorded involving a cyclist. There is a cluster of crashes on the Channel Highway within the Kingston CBD and around the intersection of Algona Road and the Channel Highway.

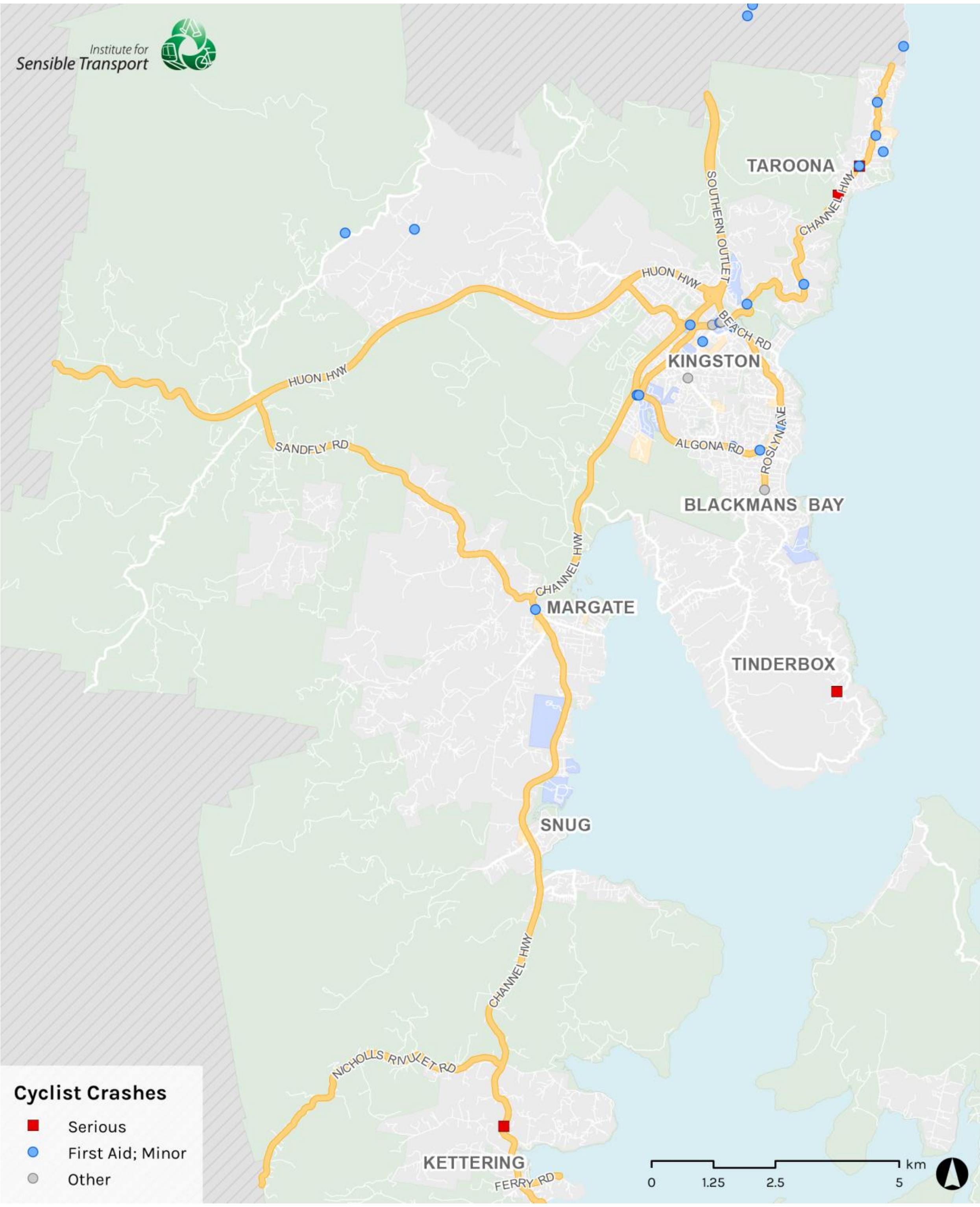

Figure 23 Cycling crashes, Kingborough

Source: Tasmanian Government

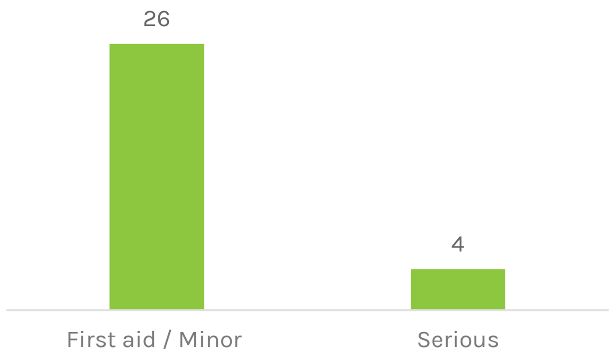

Figure 24 Cycling crash injuries within Kingborough in the last 5 years

Crashes 2016 - 2020	Broader Kingston Area	Kingston CBD Area
Fatalities	2	1
Serious	21	3
First Aid; Minor	219	71
Property Damage; Not	763	388
Total	1,005	463

Table 1 Crashes in last five years

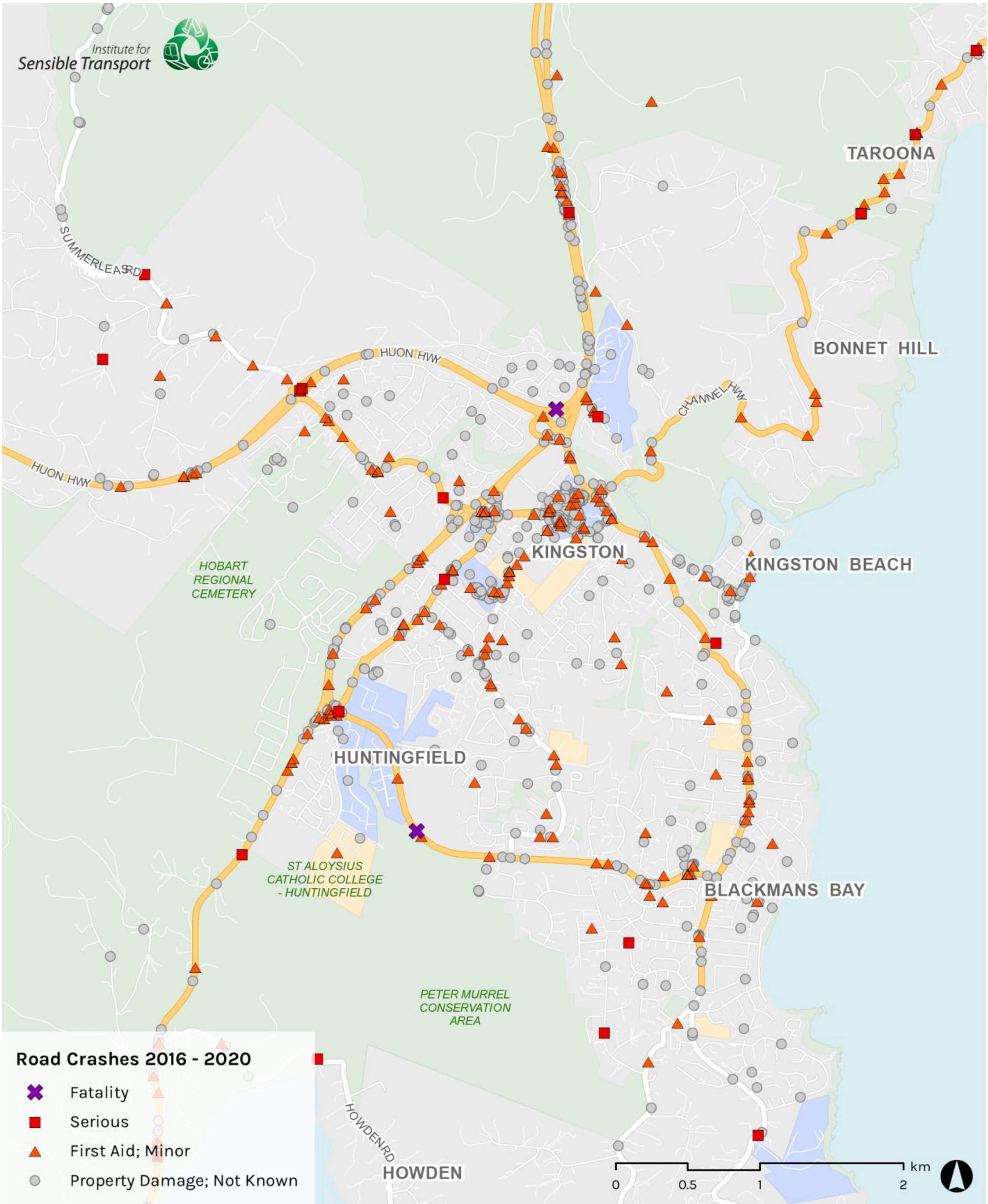

Figure 25 Crashes by severity, Broader Kingston Area

2.7 Topography

Like much of Tasmania, Kingborough consists of a hilly natural form. Many streets and roads have significant gradients. Major roads are often located along flatter valleys, as it affords easier passage and minimises construction costs. Flatter, more direct routes are most conducive to bike riding. Flatter roads, such as Beach Road, Rosyln Avenue, Algona Road, and the Channel Highway may provide an easier and more attractive option for people to ride, compared to hillier and more direct alternatives, such as Redwood and Maronoa Roads.

a

Figure 26 Topography

2.8 Bike use propensity index

High quality bicycle infrastructure in built up areas can be expensive and government budgets are limited. It is therefore important, when planning a future cycling network, to determine spatial variation in the latent demand for cycling. Through peer reviewed research, a number of Census collected variables have been isolated, in order to provide a heat map of latent demand for cycling, known as the *Bike Use Propensity Index*.

The Institute for Sensible Transport developed the Bike Use Propensity Index to identify spatial differences in latent demand for cycling in a city or region. The Index is based on eight Census collected variables that are statistically significant predictors of bike use (see Fishman, Washington, Haworth, & Watson, 2015). In sum, these maps provide a clear illustration of the spatial variation in propensity to cycle in Kingborough.

The Propensity Index can help guide areas for future investment in cycling infrastructure by identifying the areas where the greatest uptake in cycling is likely to occur. Actions focusing on high propensity areas are likely to include infrastructure projects, but should also consider behaviour change initiatives and other support programs to encourage greater cycling uptake.

2.8.1 Methodology

The Bike Use Propensity Index combines eight variables, all of which are collected as part of the ABS Census. The statistical basis for the Index was developed through the collection of data on riding behaviour and demographic factors. This data was analysed using binary logistic regression in SPSS and STATA. The results, published in Transportation Research Part A (see Fishman, Washington, Haworth, & Watson, 2015) revealed that there are some statistically significant factors for propensity to cycle.

The data that forms the basis of the Index is collected from the following variables, derived directly from the 2016 Census:

1. Residential population density, measured as people per hectare
2. Employment density measured as number of people working per hectare.
3. Density of young adults measured as number of people aged 18 – 34 per hectare.
4. Low motor vehicle ownership measured as number of households with zero or one cars per hectare.
5. Bicycle use - origin measured as number of people riding to work per hectare.
6. Bicycle use – destination measured as number of people riding to work per hectare (weighted x3).
7. City-based employment – people who work within the Hobart CBD SA2 per hectare (weighted x3).
8. Short car trips– destination measured as number of people driving to work between 0 and 5 km per hectare.

The Bike Use Propensity Index has been designed to show the variation in the relative propensity to cycle, at the highest possible level of spatial detail.

The Index contains more residential-oriented variables than it does employment, or destination, variables. To ensure that employment rich areas that have comparatively lower residential populations are not undervalued, such as the Kingston CBD, the employment variables in the index have been weighted by a factor of 3. Doing this helps ensure important bike destinations, such as employment hubs, are adequately considered in the Index.

Geographic areas that rank in the bottom quintile receive a score of 0.2 for that attribute, while those in the top quintile receive 1.0, as shown in Table 2. The mapped values are aggregates of the attributes' scores.

Table 2 Ranking system and Index categories

Quintile	Index Score
5	1.0
4	0.8
3	0.6
2	0.4
1	0.2

It is also important to recognise that SA1's that receive very high Index scores will have scored highly across all the variables included in the Index. In almost all cases, an SA1 that scores above 4.5 (out of 5) will have been in the top quintile in at least five variables.

2.8.2 Index Creation - Maps

We have used ArcGIS to create individual maps. Each of these maps provide a visual illustration of variation in propensity to cycle, based on the eight factors identified above.

In each of these maps, the Propensity Index has been recalculated. This means that in each map, SA1's can only be compared to other SA1, *in that map*. Scores cannot be compared across maps.

2.8.3 Results

The results for Kingborough's Bike Use Propensity Index are shown in Figure 27. The Kingston and Blackmans Bay areas have the highest levels of latent demand for bike riding. In particular, Firthside and Kingston between the Southern Outlet and Huon Highway were highest, as was Kingston Beach.

Blackmans Bay, particularly south of Algona Road, also scored in the top quintile, as did the residential area surrounding Hawthorn Reserve and Southern Christian College.

The Kingston CBD was ranked in the middle quintile. This is likely due to almost no residential population living within the CBD.

2.8.4 Implications

The Propensity Index has been used to help guide proposed infrastructure/network design. Areas that have a high latent demand for cycling have been prioritised, as they are likely to be generate more cycling activities than areas of low cycling propensity.

The bicycle infrastructure opportunities will include how different bike infrastructure typologies (e.g. painted bike lane, separated bike lane) can be used to maximise the appeal of cycling, especially in those areas of Kingborough with higher latent demand.

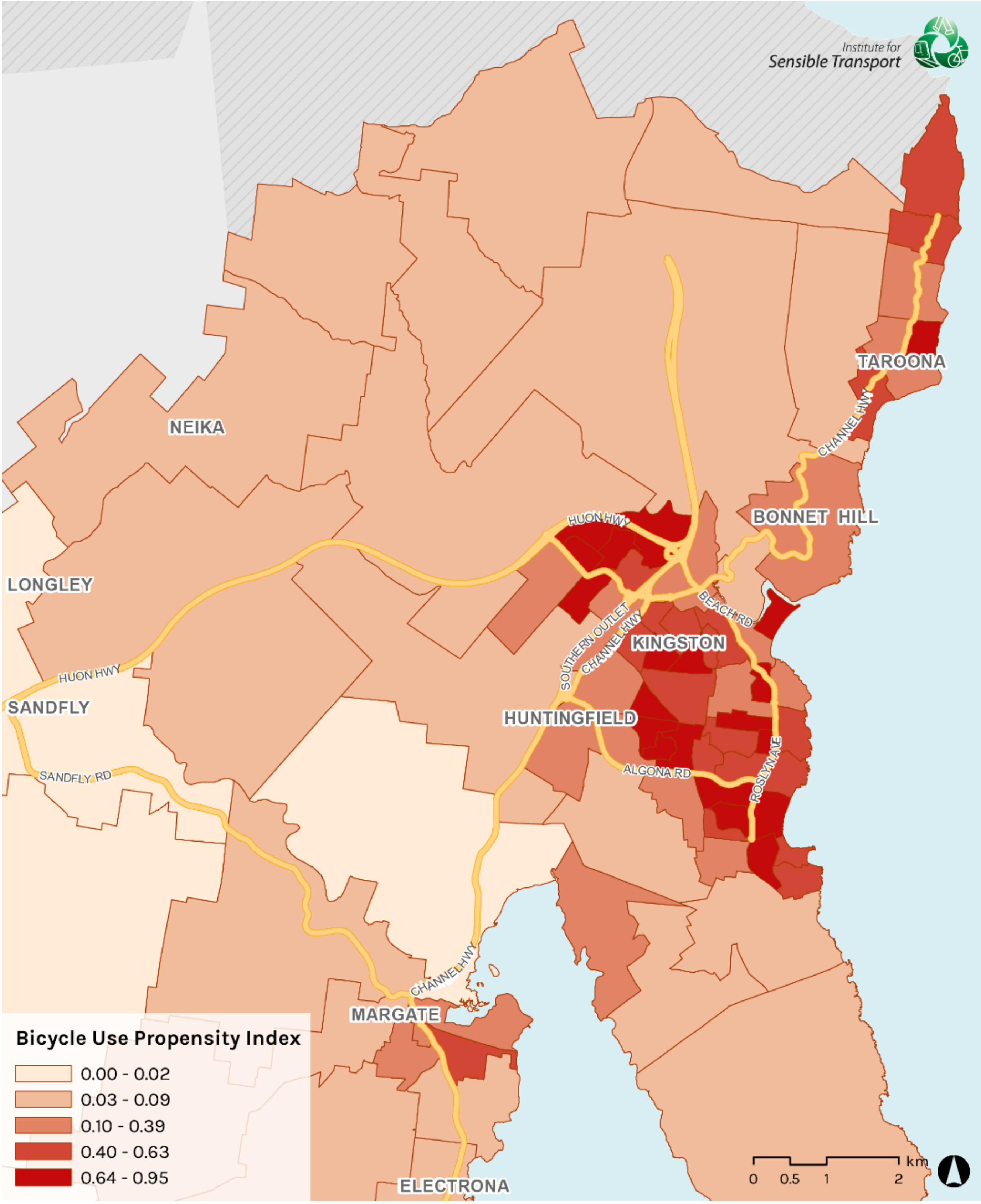

Figure 27 Kingborough Bike Use Propensity Index

Nb. This only provides analysis for adult transport cycling. Recreation, cycle to school for children, and other bike riding propensity may differ and insufficient data is available to integrate non-commute cycling.