Report
March 2023

Urban Transport Capacity, Demand and Cost: Main Report

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steer

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Executive Summary

British cities, and in particular their city centres, form the heart of the wider national economy. *Centre for Cities* estimate that, on average, nearly a quarter of all private-sector jobs in cities are based in their centres, and 9 per cent of total UK employment is located in the centres of the UK's ten largest cities, despite these areas accounting for just 0.03 per cent of all land in the UK.[1] Ensuring that urban transport networks can support and foster continued city centre employment growth is of national economic importance.

Since the National Infrastructure Commission's First National Infrastructure Assessment (NIA1), the COVID-19 pandemic has resulted in dramatic changes to urban transport demand, many of which are still evolving. Increased homeworking has led to declines in peak-hour transport demand, especially on public transport. City centre economies have rebounded from their lockdown lows, but it is still unclear the extent to which their growth trajectories will differ from those envisaged pre-pandemic.

Purpose

The future trajectory of city centre employment and commuting has important implications for the scale of peak-period capacity needed to support and facilitate growth, and hence the need for transport investment. It forms the context to the broad aim of this research:

> What scale of new urban transport capacity is required in England's largest towns and cities, and how much could it cost to provide?

Our approach involves a high-level review of current transport capacity, future city centre employment growth and what this means for future transport infrastructure requirements for the largest 54 English towns and cities, excluding London.[2] Using a set of future scenarios for the post-pandemic growth and recovery of cities and looking to 2055, we assess future capacity requirements, the scale of employment growth 'at risk' if this capacity is not provided, and 'order of magnitude' capital costs for providing this additional capacity across the 54 towns and cities as a whole.

The primary purpose of the work is to support the National Infrastructure Commission's Second National Infrastructure Assessment (NIA2), and better enable Government to plan transport investment over a long-term horizon. While our findings are considered representative of the scale of required investment across the towns and cities as a whole, it is important to note that they should not be taken as an assessment of the specific infrastructure needs or the scale of investment required in any particular town or city. Specific investment will need to be determined through local plans and strategies, and will be strongly dependent on local factors such the scale and distribution of local development and employment growth.

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[1] McGough, E. and Thomas, E. Centre for Cities (2014). '**The economic importance of city centres**'

[2] Future urban transport capacity and investment requirements in London are the subject of parallel National Infrastructure Commission study.

Current and future urban transport capacity and demand

Prior to the pandemic, we demonstrate that transport demand in several cities was at or was approaching peak-period capacity. Birmingham, Leeds and Manchester, together with Norwich, were identified as, in effect, having insufficient capacity to support additional employment. Other cities, with more 'spare' transport capacity, have a greater ability to support growth, but a risk that growth could be constrained in the longer-term.

Reflecting the major changes to working practices and commuting behaviours post-pandemic, we develop eight plausible scenarios for how city centres could grow and evolve to 2055, and what this would mean for travel demand. These scenarios are based on two key drivers:

- **Trends in homeworking** – increased adoption of remote and hybrid working has been one of the most disruptive impacts of the pandemic, with long-term consequences for both travel demand into cities, and the potential role of town and city centres in future;
- **Role of agglomeration** – partly (but not entirely) a result of homeworking, a change in the scale of productivity benefits to firms (and especially knowledge-intensive firms) of locating in close proximity to one another, which shapes the extent to which firms choose to locate in town and city centres, and hence future employment growth there.

These scenarios highlight the range of uncertainty in future demand, and the extent to which transport capacity could constrain city centre employment growth:

- An optimistic, **renaissance scenario** for city centres, with a return to pre-pandemic trends and increased homeworking countered by firms continuing to centralise in city centres, there is a large requirement for new urban transport capacity. By 2055, transport capacity is estimated to constrain growth in 15 (of 54) towns and cities, with circa 270,000 city centre jobs at risk because of insufficient transport capacity. Major expansion of urban transport networks is required if this growth is to be facilitated;
- A central **recovery scenario**, where city centres recover but higher levels of homeworking, and lower employment growth relative to pre-pandemic trends, leads to a more modest requirement for new capacity. By 2055, capacity is estimated to constrain growth in 13 towns and cities, with circa 130,000 city centre jobs at risk due to insufficient capacity;
- A pessimistic **dispersal scenario** where levels of homeworking remain high (broadly at 2021 pandemic levels) and employment growth is more dispersed away from city centres, urban transport demand remains below pre-pandemic levels in many towns and cities. There is only a limited, targeted need for new capacity. By 2055, capacity is estimated to constrain growth in just 10 towns and cities, with around 12,000 jobs at risk due to transport constraints.

Each of these scenarios, and the scale of uplift required in transport capacity, are used to estimate the total scale of investment, and associated capital cost, required across all English cities to 2055.

Suburbanisation effects

We also consider the implications of a trend towards suburbanisation within English cities, whereby increased levels of homeworking result in a greater willingness for households to move further from their city centre workplace, trading a longer commute for greater amenity value (such as a larger property or better access to the countryside). We find that this effect is likely to be small in practice, as a largely fixed stock of housing and practical limitations such as land availability will constrain the number who can move in practice.

However, for those who change location, their change in commuting behaviour will be significant. Those moving from an inner city to a more suburban location would see their average commute distance increase by more than 300%, and based on current behaviours, rail and car mode share for those who move and continue to commute increase by circa 300% and 250% respectively, predominately due to a large reduction in active travel mode share.

Across total travel demand more widely, suburbanisation effects are small, with car and rail demand increasing by circa 0.8% and 1.0% across all case study cities. However, there are potentially important implications for the type of investment required, with a greater focus on medium and longer-distance connectivity, most likely through rail, a greater focus on 'park-and-ride' connectivity, and a commensurately reduced role for local bus and active travel.

Infrastructure requirements and potential capital costs

We develop three broad approaches for how additional capacity could be delivered in practice – bus-based, transit-based and rail-based. Each refers to the primary mode through which investment is targeted and additional capacity provided, but each includes investment across modes.

Based on these approaches, we estimate the order of magnitude capital costs associated with increasing urban transport capacity across the 54 towns and cities:

- With the optimistic, **renaissance scenario**, capital costs are substantial, at circa £36bn for a transit-based approach and £47bn (2022 prices) for a rail-based investment approach. These figures are comparable to the NIA1 assessment. To cater for peak period demand, in this scenario large cities require major new or expanded light rail networks, and/or very high-cost rail investment, likely including tunnelled infrastructure in a small number of cities. The scale of additional capacity required is above that that could be feasibly provided by a bus-based approach.
- In the central **'recovery' scenario**, capital costs are lower, ranging from circa £5bn for a bus-based, £11bn for a transit-based and £18bn for a rail-based approach when summed across the 54 towns and cities. These sums reflect the lower scale of capacity that is required compared to the renaissance scenario and this is predominately due to a greater level of homeworking. This highlights:
    i. A bus-based approach, with a focus on delivering capacity through priority infrastructure and new Bus Rapid Transit (BRT) services, can be delivered at relatively low cost. However, existing street constraints mean that this may not be feasible for every town and city, and it would likely also require changes to operating practices such as double-door operation and simpler ticketing;
    ii. Both transit and rail-based approaches would require greater investment, but the nature of this investment is typically more incremental when compared to the transformatory uplift in the renaissance scenario. Capacity is provided largely through incremental expansion of existing light rail networks (or new networks in cities without one), and/or station upgrades, platform lengthening and signalling enhancements on the rail network.

- In the pessimistic **dispersal scenario**, capital costs are small, at circa £200m for both a bus- and transit-based approach, and £800m for rail. This reflects the very small overall requirement for additional capacity relative to pre-pandemic, with high (pandemic) levels of homeworking and lower employment growth resulting in a decline in travel demand compared to 2018 and hence little need for additional capacity.

Our work highlights that infrastructure costs do **not** increase linearly with the scale of capacity required, especially for rail. Some capacity can typically be gained at relatively low marginal cost, such as by lengthening existing trains, but above a certain threshold large-scale investment is required at significant cost. Both this threshold, and the cost of enhancing capacity, are unique to the specific city and travel corridor in question. Additional transport capacity is much easier and cheaper in capital cost terms to provide in some cities than others.

Reflecting these uncertainties and the high-level approach adopted, each of these cost estimates is accompanied with a **wide range** of uncertainty. This scale of uncertainty is specific to each combination of scenario and investment approach, but averages -40% and +100% relative to the figures set out above.

Potential role of demand management

We also assess the potential role of demand management as a policy tool in large towns and cities, both to better manage road space and facilitate growth, and support wider local objectives. Tools considered include:

- **Congestion charging**, based on charging vehicles crossing a specific cordon and/or travelling within a charging zone, similar to London's Congestion Charge;
- A **Workplace Parking Levy**, based on an annual charge for workplace parking, similar to that implemented in Nottingham;
- **Physical demand management**, which includes a range of measures to restrict access to traffic, including city centre bus gates, traffic filters and/or Low Traffic Neighbourhoods.

We conclude that **congestion charging** could play an important role in reducing traffic volumes and congestion within the largest cities, and encouraging a shift to public transport, while raising significant revenue to support and fund local transport improvements. It is likely to be most effective in the largest cities, and/or those with the most comprehensive and mature public transport networks, as it is these cities where alternatives to the car are already more viable, and there is a reduced potential for negative local economic impacts by discouraging trips to city centres. We also highlight that congestion charging could support a wider range of benefits, including:

- **Faster (and more reliable) journey times** arising from reduced traffic congestion, both for remaining traffic and for bus passengers;
- **Social and environmental benefits**, including improved air quality and a reduced negative impact of traffic on the streetscape and urban environment;
- **Greater opportunities for road space reallocation**, including greater priority for buses (or trams), improved segregated cycling provision and/or urban realm improvements;
- A **major additional source of revenue** for improved public transport services and/or capital investment, funding transport improvements which could otherwise be unaffordable. Based on high-level modelling, we assess that congestion charging **in city centres only** could generate annual revenues (net of operating costs) of circa £20-60m in each of the largest eight cities outside London.

We conclude that implementation of a **workplace parking levy** could also act as a significant revenue source to fund local transport enhancements. High-level modelling **at a local authority level** indicates that annual net revenues range from £20-30m in the largest cities

(Birmingham and Manchester) and £5-10m in most small and medium sized cities. However, the price point of a WPL (equivalent to circa £2 a day), and that it is only applied to a small subset of traffic (car commuting to a workplace with parking), means that it is unlikely to yield significant net impacts on traffic volumes and/or large-scale social and environmental benefits.

We note that **physical demand management** is likely to be most effective at deterring short-distance traffic movements, and encouraging local mode shift, especially to walking and cycling. In isolation, it is less likely to generate significant changes in traffic volumes for longer-distance journeys to and from city centres. However, it can form an effective means of re-allocating road space to more space-efficient modes (walking; cycling; and public transport), deliver local environmental benefits, and second-order health benefits through greater active travel.

Implications for capacity requirements

Introducing demand management is likely to require greater public transport capacity and/or connectivity to accommodate demand transferring from car, and to increase the public acceptability of proposals. However, dependent on the specific context, demand management can also help cater for additional employment-induced demand by better using existing road space, and enabling additional capacity to be more efficiently introduced and at less cost. Revenue from charging-based approaches can also help fund transport improvements.

Successful demand management should change the balance of use of the different modes available. However, we note that if demand management reduces overall demand (‘active restraint’), this could result in negative local economic consequences should employment growth or other economic activity be deterred.

1 Introduction

Background

1.1 This study, **Urban Transport Capacity, Demand and Cost,** has been developed to:

- understand the broad future requirement by 2055 for additional peak-period urban transport capacity to the centres of the largest 54 towns and cities in England excluding London;
- assess the potential scale of capital cost of additional transport investment to provide this capacity;
- consider the potential role of demand management in large towns and cities, and how it could influence the need for transport investment.

1.2 Reflecting the inherent, post-pandemic uncertainty in both future commuting demand, and employment growth in city centres, we use a range of scenarios to consider future capacity requirements. These capture a range of alternative futures for city centres. The highest demand and hence capacity requirements arise from a 'renaissance' for city centres scenario in which travel demand rebounds, driving the case for large-scale public transport investment. The lowest demand scenario, with more dispersed employment growth away from city centres, combined with high levels of homeworking, results in stable or declining travel demand to city centres and a materially lower need for additional urban transport capacity and capital investment. A number of intermediate scenarios are also considered.

1.3 Together, the scenarios are used to highlight both the range in potential investment requirements, and the key drivers of urban transport demand in the future. They form the basis of the assessment of the scale of capital costs, and highlight how the need for investment is strongly dependent on the future role, and post-pandemic growth, of England's largest towns and cities.

Purpose

1.4 The study is intended to inform the development of the National Infrastructure Commission's (NIC's) Second National Infrastructure Assessment (NIA2), and broadly follows the approach of a piece of work undertaken by Steer to support the First National Infrastructure Assessment (NIA1) in 2018.[3] This study forms part of a suite of parallel studies, which taken together will inform the NIC's understanding of the overall cost envelope of increasing urban and interurban transport capacity and the likely economic benefits of doing so.

1.5 While the study's outputs are considered representative when aggregated across cities, they should not be taken as an assessment of the specific infrastructure needs or the scale of investment required in any particular town or city. Although the outputs highlight cities with a greater need for investment, and those where capacity is most constrained, this assessment is based on the growth projections and assumptions that underpin each of the demand

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[3] Steer Davies Gleave (2018) **Urban Transport Analysis: Capacity and Cost**

scenarios. These projections account for forecast population growth and the change in the working-age population, but do not consider different levels of economic growth between cities as a result of their local characteristics or economic strengths, or local and national policies.

1.6 Looking to 2055, some cities will exceed their growth projections while others will trail behind, and the rate of growth in each city will have a material effect on the scale of infrastructure required to accommodate that growth. This work is intended to highlight the broad number of towns and cities that may require large-scale investment to increase capacity, what this investment might look like on the ground, and what it could cost, aggregated across all 54 towns and cities as a whole. It should not be interpreted that any one town or city requires investment over another; this would require more detailed local economic forecasting and assessment of local transport constraints.

1.7 Variations between our assessment of both capacity requirements and infrastructure costs and locally derived transport strategies, plans and programmes is hence anticipated. While this study considers potential interventions to achieve a range of transport capacity uplifts, it is not suggested that such interventions are necessarily required to meet local policy goals. Specific plans and programmes for individual cities need to be developed at a local level, taking into account local context and need, as well as consideration of deliverability, affordability and value for money.

1.8 Although the majority of the analysis has been focused on twenty case study town and city centres (referred to as 'cities' for the remainder of this report), the approach has been developed to be sufficiently generic to allow extrapolation of its findings to the 54 largest English towns and cities outside London.

Approach

1.9 There are many possible approaches to developing the outputs required of this study. The adopted methodology for this study is based on five stages. Each is discussed in a Chapter of this report. The Stages are:

Stage 1: Assessment of baseline transport capacity and demand

- Review and update our previous assessment of pre-pandemic, 2018 transport demand and capacity into the 20 case study cities (the 'baseline');
- Determine the ability of each city to support future employment growth under baseline conditions.

Stage 2: Exploring future urban, city centre transport demand

- Develop a range of scenarios for future peak-period commuting demand into city centres, arising from two key drivers – future levels of homeworking and the role of agglomeration within cities;
- For each scenario, estimate the extent to which current transport capacity will constrain future employment growth;
- For each scenario, estimate the scale of additional transport capacity required to deliver future employment growth, and avoid growth becoming constrained.

Stage 3: Approaches for increasing urban transport capacity

- Develop three investment approaches for how future capacity in large towns and cities could be provided – bus-based; transit-based and rail-based;

- Derive a series of 'capacity uplift scenarios' which dictate both the scale of additional capacity required in cities, and the modes through which it is provided.

Stage 4: Understanding the potential role of demand management

- Review the potential types of demand management that could be implemented in an urban context in England's largest cities;[4]
- Drawing from case study evidence, assess the implications of each approach for mode shift and urban transport capacity;
- Discuss the potential role of demand management within the case study cities, and the wider benefits and costs of the three approaches.

Stage 5: Implications for infrastructure requirements and capital costs

- Determine the broad scale of increased infrastructure required to deliver the increase in capacity stipulated in the capacity uplift scenarios – in terms of new rolling stock, tram lines and rail enhancements, etc.;
- For the 20 case study cities and wider 34 largest English towns and cities outside London, cost this infrastructure on the basis of established unit rates and professional judgement;
- Explore the potential range of future operating costs, revenue and subsidy requirements, and the key factors which influence them;
- Assess the potential scale of revenue and operating costs of the three demand management approaches.

Case study cities

1.10 Twenty case study cities are used as a basis for the study, chosen to reflect a range of different city sizes, locations and socio-demographic contexts. The selection does not reflect any assessment of investment priorities, either nationally or in the case study cities, or suggest that these case study cities have a greater need for transport investment than other locations. They have been chosen simply to ensure that the case study cities represent a broad range of England's town and cities.

1.11 The twenty case study cities can be broadly grouped into large, medium and small groups based on their primary urban area population, and this categorisation is used to group cities within the analysis. The case study cities (and their population bands) are:[5]

Birmingham (L)	Leicester (L)	Telford (S)
Manchester (L)	Southampton (M)	Burnley (S)
Newcastle (L)	Reading (M)	Plymouth (S)
Sheffield (L)	Preston (M)	Swindon (S)
Leeds (L)	Middlesbrough (M)	Exeter (S)
Bristol (L)	Coventry (M)	Norwich (S)
Liverpool (L)	Huddersfield (M)	

[4] Our review of demand management is focused on three approaches – urban 'congestion' charging; workplace parking charging; and physical traffic management – that could be adopted in the short- to medium-term, using existing technology. We do not consider more 'radical' approaches, such as distance-based charging using GPS technology.

[5] Note that for the utilisation normalisation (discussed in Chapter 3) and the analysis of suburbanisation effects (Chapter 4), a further 'Very Large' population band is used. This is a subset of 'Large', and includes Birmingham, Bristol, Leeds, Liverpool and Manchester only.

1.12 Results are also extrapolated to a further 34 English towns and cities, as discussed in Chapter 7, to provide an order of magnitude estimate of the potential scale of required investment in additional urban transport capacity across England (outside London) as a whole.

2 The Challenge

Study context

2.1 Transport networks play an essential role in supporting the economy and facilitating economic growth. Improved transport connectivity can support and facilitate economic growth through:

- increasing productivity of existing economic assets (land, capital, etc.);
- improving the efficiency of the labour market;
- supporting sustainable housing and employment growth; and
- enhancing the attractiveness of places as locations for investment.

2.2 City centres play an integral role in both the economies of UK cities, and the national economy as a whole. Ensuring sufficient transport capacity (and connectivity) to city centres is especially important, as it is these locations where employment (and in particular high-skill, high-value employment) is most concentrated.[6]

2.3 Businesses benefit from the proximity, or 'agglomeration', that city centres offer through sharing infrastructure, the ability to recruit from a larger labour pool and the ability to share knowledge, ideas and information. Insufficient transport capacity (and connectivity) risks undermining these productivity benefits, displacing employment to other less optimal locations, and hence undermining wider national productivity and economic growth.

2.4 The purpose of this study, reviewing future urban transport capacity requirements and the cost of increasing that capacity, is set in this context and the context of the wider public policy goal to support economic growth. Our work highlights the extent to which transport capacity could constrain future city centre employment growth, and the broad scale of investment required to overcome these constrains.

2.5 Transport capacity in this study is considered in the context of providing access into city centres only. All analysis is based on trips during the busiest morning 'high peak' hour (08.00 - 09.00).

The end goal

2.6 Ultimately the results of this study are structured around answering the questions:

- What was the pre-pandemic capacity, demand and utilisation of urban transport networks?
- How could future urban transport demand vary in a range of potential future scenarios – each with different levels of homeworking, employment growth and the future role of agglomeration within cities?
- In these scenarios, to what extent could current capacity constrain future employment growth?

[6] For further detail on the key role of city centres within the national economy, see: **The economic importance of city centres | Centre for Cities**

- What could different levels of uplift in transport capacity look like?
- What would be the broad cost to sufficiently uplift capacity to avoid employment growth becoming constrained?

What is the current capacity, demand and utilisation of urban transport networks?

2.7 There is no perfect way to determine a single value that represents capacity across an entire urban network. While each individual element of a transport network has a definable capacity, for a system formed of a combination of those elements it is much more difficult to determine a single numeric value.

2.8 The way in which the system is used on any given day can change, affecting the overall capacity available to an individual accessing the city centre. For example, a single seat on a bus can provide capacity for multiple people along a route as different passengers board and alight in different locations along the route, or increasing the number of buses travelling into a city centre may reduce the capacity available for private car travel. Not all capacity is readily available for use – for example, some rail corridors may have significant spare capacity, but this is of no use to an individual if they reside on a different corridor where all the trains are already 'full'.

2.9 Nonetheless and recognising that it is a simplification, in our analysis we adopt a single 'utilisation' metric to capture the scale of capacity and demand across modes and the level of 'spare' capacity in the network. This is discussed in Chapter 3.

What is the future demand on urban transport networks?

2.10 It is very challenging to forecast long-term transport demand into city centres. This is a result of uncertainties including macroeconomic factors (such as local employment growth) as well as long-term behavioural uncertainties notably those arising from the pandemic such as increased homeworking, and those pertaining to the role of agglomeration (which partly dictates how employment is concentrated in city centres).

2.11 We have adopted a range of scenarios that capture these uncertainties, with very different visions for how city centres could develop and grow in future. The highest demand and hence capacity requirements come from a city centre 'renaissance' scenario where travel demand rebounds, driving the case for large-scale public transport investment. The lowest demand scenario has low city centre employment growth, combined with high levels of homeworking, resulting in stable or declining travel demand to city centres and a materially lower need for additional urban transport capacity and capital investment. A number of intermediate scenarios are also considered.

2.12 Each scenario has materially different implications for future urban transport capacity, and hence investment requirements. We do not comment on which scenario may be more likely in practice, but instead highlight the key sensitivities that could influence future urban transport demand, and hence the need for large-scale infrastructure spending. At the time of writing, as cities slowly adapt to a post-pandemic 'new normal', the medium- and long-term implications of the pandemic remain uncertain.

How can transport capacity constrain employment growth?

2.13 There is no definitive mechanism through which limited transport capacity can constrain employment growth. Consider an individual offered a job within a city centre where the transport network is operating near capacity with very high levels of crowding. They would be faced with several choices:

- Commute to the job, during the high peak hour, and endure a more difficult, crowded and/or longer, less reliable journey than if they travelled at other times;
- Commute to the job, but instead in the quieter but less convenient shoulder peak period;
- Work more often from home, and only attend the city centre workplace if essential (if the job allows this);
- Take a different job, outside a city centre, with fewer transport constraints;
- Work fewer hours and so commute less often, or not work at all (e.g. take early retirement).

2.14 Strictly, only the last two of these choices would result in transport capacity 'constraining' city centre employment growth and only then if no one else is prepared to take the position. But each also results in welfare and/or economic disbenefits to the individual and/or their employer. Choices facing individuals will also be different based on the employment, industry and the opportunities available to them, resulting in a different willingness to tolerate crowded conditions or travel at different times. Additionally, severe crowding, congestion, slow journey times and/or poor reliability – all which typically occur alongside capacity-constrained transport networks – undermine the productivity advantages of cities, and the decision of firms to locate there in the first place.

2.15 We account for this by 'normalising' our measure of the available 'spare capacity' on each city centres transport network, and then assuming that once this capacity is 'used up' by increased employment and commuting demand, employment growth becomes constrained and no further growth can be accommodated by the transport network. This is a simplified representation of how transport capacity can act as a constraint, but proportionate in the absence of more detailed modelling exploring the relationship between observed employment growth, transport capacity and crowding in different cities.

2.16 A further simplifying assumption implicit in our approach is that transport capacity is the singular potential constraint to city centre growth. In reality, there can be other constraints, for instance the availability of land to develop new premises. Cities also compete with each other for footloose investment and factors other than transport and site availability can be important considerations.

What could a capacity uplift look like?

2.17 Providing a representation of what a given uplift could 'look like' is based, for the purposes of this study, on technology and modes that are currently widely utilised in Britain. Technology, and its interface with the transport system, is constantly developing. However, until new technologies are implemented, including the enabling regulations, it is difficult to project how their impact on urban mobility will be manifested.

2.18 Defining how capacity uplifts could be delivered is based, therefore, on current contemporary themes in delivering transport infrastructure. Four core modes are the focus of the scenario building (bus, rail, light rail and private vehicle). Some consideration is also given to active modes; however, such modes are only appropriate for relatively short trips and therefore their potential contribution to the provision of capacity for a range of trip purposes and journey lengths is limited.

Contemporary themes in transport planning

2.19 Over time, as the transport knowledge-base expands and societal preferences evolve, the way in which transport capacity is delivered is changing. This is most notable in the shift away from prioritising the car as a mode, and is also reflected in a much wider range of decisions which has informed our approach to considering how future capacity could be provided. These themes include:

- Implementation and extension of light rail networks in large cities;
- Light rail/metro aspirations, including commissioning of studies, in medium cities;
- Measures to reduce private vehicles trips to and across city centres, including through physical restrictions, road space reallocation and/or charging measures;
- Planning and implementation of integrated Bus Rapid Transit (BRT) networks;
- Investigation of tunnelled metro/public transport infrastructure due to city centre space constraints;
- Ongoing upgrades to/optimisation of urban road networks to release capacity constraints.

How much will it cost?

2.20 The cost of delivering transport capacity uplifts varies by location and can be affected by a range of factors, including but not limited to:

- The type and scale of infrastructure required, from ‘incremental’ enhancements to ‘transformational’ investment;
- Ease/difficulty of implementation;
- Material and transport costs;
- Land-take and compulsory purchase requirements; and
- Impact on the existing, operational transport network.

2.21 Urban transport schemes are likely to become costlier over time. This outcome is anticipated due to a range of factors including changes to minimum standards, greater user expectations and exhaustion of ‘low hanging fruit’, meaning schemes delivered later are often more complex.

2.22 This potential trend is not considered explicitly within this study; however, it is partly accounted for to some extent by the scale of infrastructure assumed relative to a given capacity requirement, and an increased need for higher-cost interventions at the highest capacity requirements. That is, infrastructure requirements for the highest capacity uplifts are considered to be transformational in nature (e.g. including new tunnelled tram or rail lines across city centres), whereas requirements for the lowest capacity uplifts can be more likely achieved through smaller-scale increments to the existing transport offer in a given city.

2.23 Cost estimates developed in this study are intended to be appropriate for scaling across all English cities. However, they are not developed to a level of detail that allows specific local features to be accounted for in the costs.

Interpretation of findings

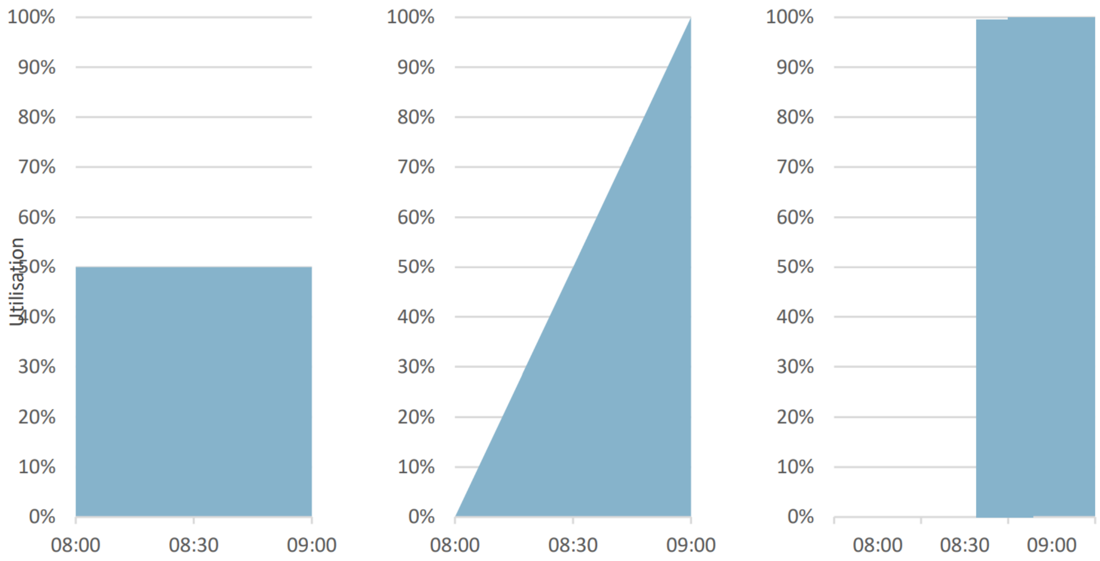
2.24 In assessing the city-specific capacity requirements, defining the capacity uplift scenarios, and estimating the capital costs of delivering these uplifts across the twenty cities, it has been necessary to make a large number of assumptions. As far as possible we have drawn upon relevant, publicly available datasets and evidence sources to inform and support the assumptions applied, however an element of professional judgement has also been necessary. Detailed commentary related to these assumptions and the data sources used to inform them is included in the subsequent chapters and the Methodology Report.

2.25 Consequently, the results of this study are appropriate for application in the context for which they have been developed. However, it is important to understand the limitations of the results and how these results should be interpreted. The remainder of this section includes commentary regarding appropriate use and application of the study outputs and brief discussion of relevant, but out-of-scope issues.

Network utilisation

2.26 Utilisation results, as reported in Chapter 3, represent utilisation over the 08.00 – 09.00 peak hour. Many cities experience a 'peak within a peak', where the network is busier for certain periods within the peak hour, but not consistently busy at the same level across the full hour. For example, where an average utilisation value of 50% is reported, this could represent a consistent utilisation of 50% of available capacity across the whole peak hour, a gradual increase in utilisation from 0% to 100% across the peak hour, or utilisation of 100% for 30 minutes only (50% of the peak hour), as demonstrated in Figure 2.1.

Figure 2.1: '50% utilisation' examples

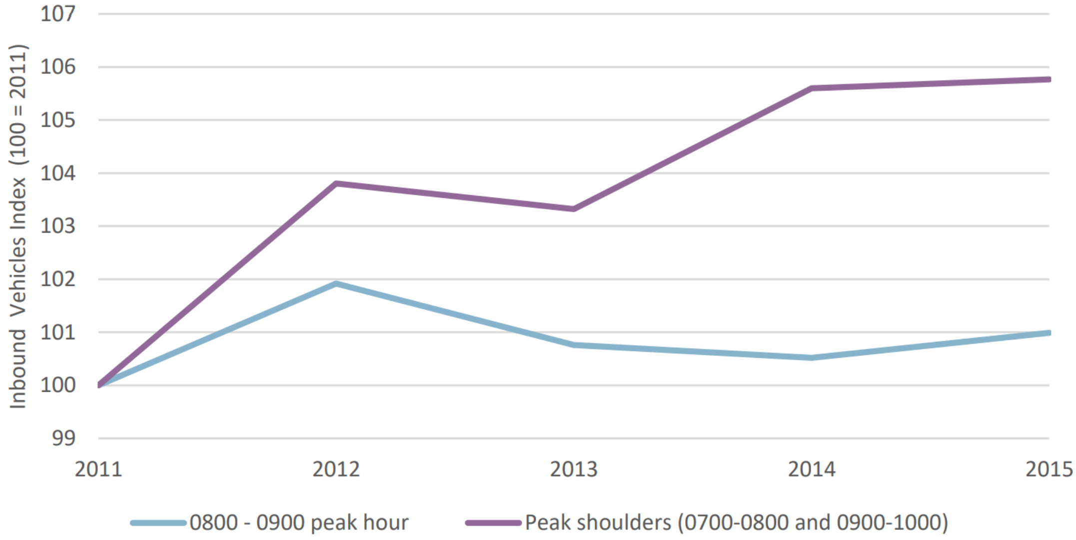


Peak Spreading

2.27 This study assumes that the key trips of interest occur during the morning peak hour (08.00-09.00) and will continue to occur at this time. In reality, some cities have a propensity for peak spreading, where trips that would ideally be undertaken during the peak hour are undertaken during the hours either side of the peak (peak shoulders). An example of this phenomenon, measured in Leeds, is shown in Figure 2.2.

2.28 Peak shoulder traffic counts are shown to increase over time, showing that overall trip numbers are growing, while morning peak hour counts show negligible change. This is considered to be due to the network operating at capacity in the high peak hour.

Figure 2.2: Peak Spreading across Leeds City Centre Cordon (morning peak)



Source: Leeds Central Cordon: 2015 Traffic Flows

2.29 Our assessment is focused on capacity in the peak hour only, and does not explicitly consider propensity for peak spreading. If, in response to the peak hour transport network operating at capacity, individuals continue to work and commute in city centres but travel in the shoulder peaks, this will result in a reduced level of transport constraint on city centre employment, and a reduced need for capital investment to increase capacity to that presented within our results.

Transport interventions

2.30 Where possible, scenarios include the 'lowest cost, realistic' approach to providing the defined capacity uplifts. This, by extension, also requires consideration of the available policy levers at a local level. Generally, this includes a combination of interventions across all modes, starting from incremental increases to existing transport provision towards transformational interventions under the highest capacity requirements.

2.31 It should be highlighted that our focus is on interventions to **solely** increase transport capacity, rather than wider connectivity across cities. This has two important implications:

- Some cities, particularly under the low scenarios, do not have a requirement for additional city centre transport capacity at all – and consequently do not incur a requirement for transport infrastructure investment.[7] This is **not** to say that that these cities do not require any infrastructure investment at all – for example, to improve the quality, frequency or coverage of their public transport networks, aspects which are not the focus of our study – but instead that they **do not** require investment to **solely** increase capacity.

- Our cost estimate only includes the 'lowest cost, realistic' approach required to increase capacity. Particularly for rail, it may be the case that alternative types of investment which increase capacity alongside other objectives may represent better value-for-money, such

[7] For example, for where cities already are deemed to have extensive 'spare' capacity (e.g. Liverpool), where employment growth is projected to be modest, and/or where there is a high reduction in travel demand as a result of increased homeworking.

as electrification, rather than simply running longer and/or more frequent (diesel) trains as assumed within our cost estimate.

2.32 Packages of interventions are defined in broad terms by a series of guidelines, rather than taking a city-by-city approach to defining how capacity could be increased in specific cities. This approach is sufficiently generic to allow the extrapolation of results across all English cities. It is not suggested that the implied mode investments are required, or justified, in each individual city. Specific plans and programmes for individual cities should be developed at a local level, taking into account local context and need, as well as consideration of affordability and value for money.

Aggregation of cost estimates

2.33 Cost estimates for the capacity uplift scenarios are intended to be used in aggregate across multiple cities, as opposed to on a city-by-city basis. Assumptions associated with the transport interventions within each scenario are made on the basis that investment in some cities may be overstated, and understated in others. Considering the results in aggregate ensures any over and underestimates countervail each other to provide a representative order of magnitude cost estimate at an aggregate level.

3 Baseline Transport Capacity and Demand

Introduction

3.1 This Chapter summarises our assessment of pre-pandemic transport demand, and capacity, of the transport networks that cross the city centre cordons of each case study city, and their ability to support future employment growth with a baseline, pre-pandemic, set of planning assumptions. It sets out:

- the estimated transport capacity, versus 2018 demand of each city;
- the **normalised utilisation** of each city's transport network – in effect, this is a measure of the scale of spare network capacity, reflecting that no network can operate 100% efficiently;
- based on this, the ability of the transport networks in each city to **support future employment growth** under the baseline conditions.

Current transport demand and capacity

2018 demand and theoretical capacity

3.2 The basis of the assessment of future urban transport capacity requirements is **pre-pandemic** 2018 demand and capacity. The choice of 2018 reflects:

- Commuting demand has fallen and then to an extent recovered since the start of the pandemic, with short-term effects still present. Different cities have been effected in different ways. There are also wider compounding effects such as inflation and the cost-of-living crisis. Together these effects mean that there is uncertainty about how representative current demand is and the extent that this forms a suitable base to assess future demand;
- In many cases, public transport current capacity is also reduced compared to 2018, reflecting a decline in demand and in some instances, short-term staff shortages. However, in most cases this capacity can be quickly restored, if required, to meet demand without incurring capital cost.

3.3 The basis for our assessment is therefore the 2018 demand and capacity data previously reported in our work that supported NIA1. However, several small updates have been made:

- a refinement of the approach used to estimate 2018 bus demand and capacity;
- updates to account for committed investment in new urban public transport capacity, where these result in a material increase in inbound capacity crossing the city centre cordons. Notable in this regard is the new rolling stock fleet on Merseyrail and the Tyne-and-Wear Metro.

3.4 Figure 3.1 summarises the 2018 transport demand crossing each of the city centre cordons, by mode, with the remaining 'theoretical' capacity shown in **grey** (that is, the difference between the assessed total capacity and demand). This highlights the broad scale of demand relative to the theoretical capacity provided, and that when assessed in these terms, most cities have significant ‘spare’ theoretical capacity. Although this varies across cities and modes, in simple terms even in the high peak hour, the assessment is that there are spare seats and standing spaces on buses and trains crossing the city centre cordons; and not every highway crossing the cordon is 100% utilised.

3.5 However, the scale of spare ‘theoretical’ capacity does not provide a sound basis for understanding how in practice demand can increase on the network. Traffic congestion and other constraints on the network upstream from the city centre cordon will mean that not all theoretical highway capacity can be used; on public transport, some capacity is inevitably ‘wasted’ as it is provided on corridors where it is not required to the extent provided, or where specific services cannot be perfectly matched to the spatial and temporal patterns of demand. High frequency bus services, for example, inevitably bunch together, meaning the total available capacity cannot be fully used. Taken together, these and other effects mean that it is virtually impossible for every bus to arrive 100% full in a city centre.

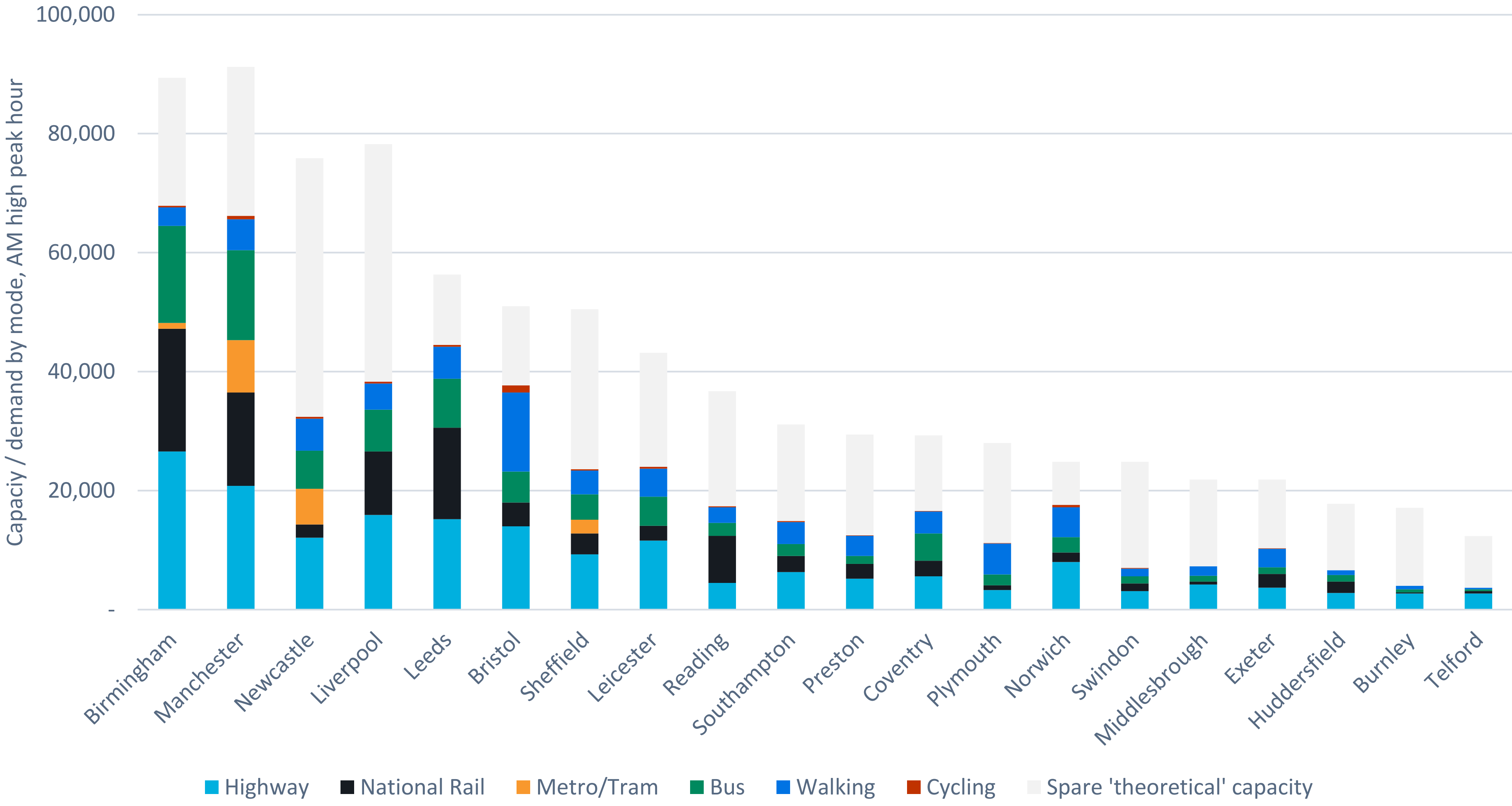
Capacity normalisation

3.6 It is therefore necessary that the assessment of future urban capacity and investment requirements is based upon a more realistic measure of capacity, rather than the theoretical aggregate capacity of every road, bus and rail service. We therefore ‘normalise’ the capacity to create a more realistic measure of how much spare capacity there is to support future employment growth.

3.7 This is undertaken by applying a series of ‘normalisation factors’ which reduce the scale of assumed network capacity within the assessment. These factors vary by mode and broad size of city, reflecting both that city size affects the efficiency of the network, and those living and working in larger cities are typically more willing to tolerate more crowded conditions.[8]

[8] Within larger cities, the public transport network can generally be better planned to match demand (e.g. rail services planned around a specific peak capacity requirement at a city centre terminus, rather than simply capacity over a long-distance intercity route). The factors are hence higher in larger cities. Further detail in provided in the Methodology Report.

Figure 3.1: AM high peak hour demand and spare 'theoretical' capacity across each city centre cordon, 2018 estimated



3.8 Reflecting the sensitivity of the results to the different factors adopted – the choice of factors directly affects the scale of spare capacity, and hence the ability of the city to support employment growth – we have tested a range of different factors to convert from theoretical to realistic capacity for each mode. These factors were derived from analysis of cities where peak-hour demand growth has plateaued but is still occurring in the shoulder peak (such as highway demand in Leeds, as shown in Figure 2.2), benchmarking and professional judgement. Two sets of factors were developed and tested, summarised in the table below.

Table 3.1: Summary of normalisation factors tested for study

	'Low' factors – adopted for the study *Lesser ability to support employment growth within current capacity constraints*			**'High' factors – used as sensitivity test** *Greater ability to support employment growth within current capacity constraints*		
Mode	Very Large	Large	Medium and Small	Very Large	Large	Medium and Small
Highway	0.7	0.6	0.5	0.8	0.7	0.6
National rail	0.6	0.5	0.4	0.7	0.6	0.5
Metro/tram	0.6	0.5	N/A	0.7	0.6	N/A
Bus	0.6	0.6	0.6	0.7	0.7	0.7
Walk/cycle	1.0	1.0	1.0	1.0	1.0	1.0

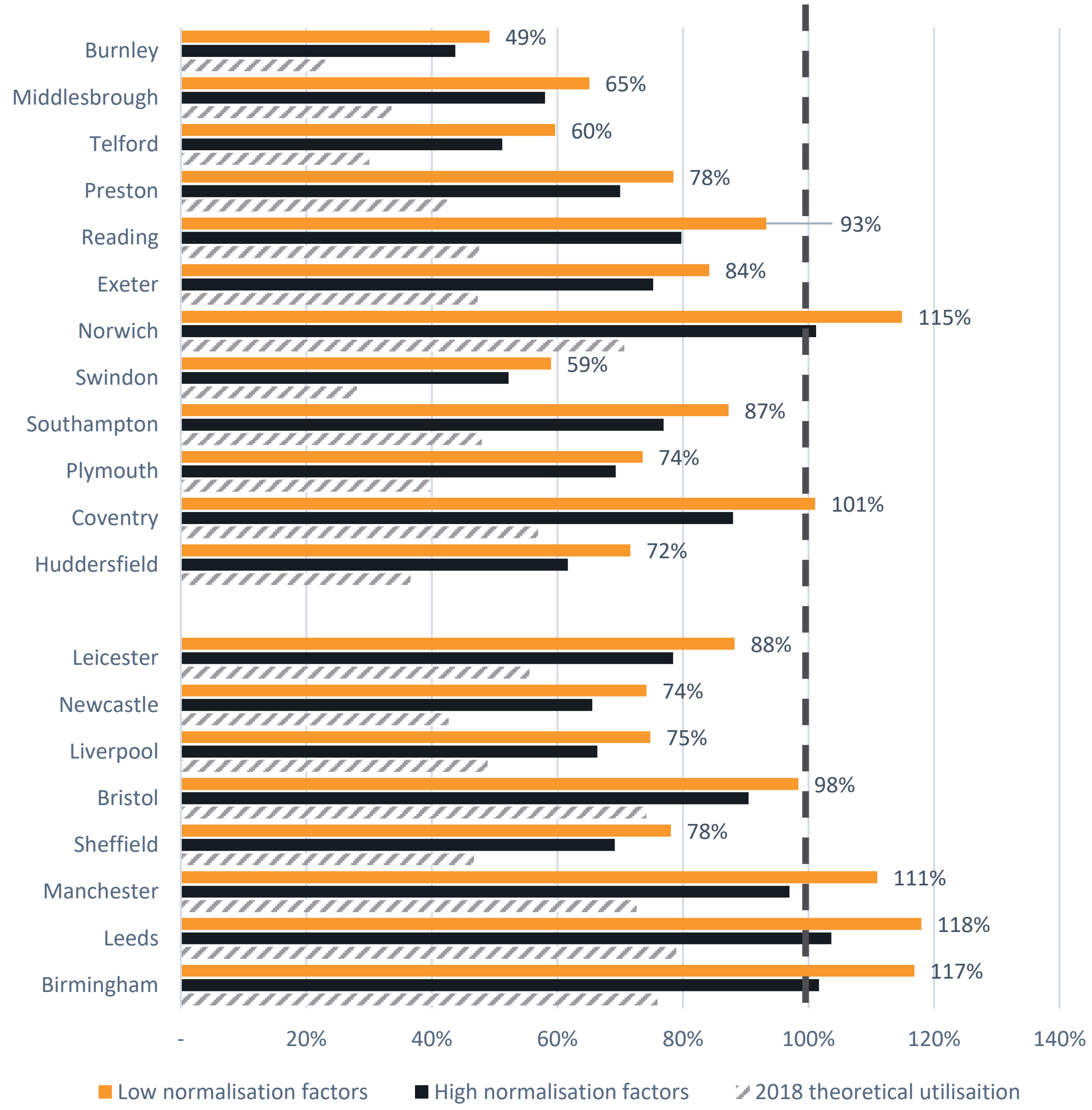
3.9 For example, consider a bus service of 10 double-decker buses per hour crossing the city centre cordon, with a theoretical capacity of 870 (bus capacity of 87 x 10). The individual bus capacity of 87 is made up of 72 seats and 15 standees. If, on average, about two thirds of the seats on each bus are taken and there are no standing passengers, this equates to about 475 people (72 seats x 0.66 x 10), and spare 'theoretical' capacity for 395 extra people (i.e. 870 – 475). Applying the normalisation factor of 0.6 to the 'theoretical' capacity of 870, however, results in a 'realistic' capacity of the bus service of 522. Hence, the spare 'realistic' capacity is just 47 people (i.e 522 – 475), which is far less than the 395 that a theoretical assessment would suggest.

3.10 Figure 3.1 summarises this normalised network utilisation (demand as a percentage of capacity) across the different cities, applying the factors in Table 3.1 for each mode to each city, noting that:

- The **grey** dashed bars show the theoretical utilisation within each city – before the normalisation factors are applied;
- The **black** bars show the normalised utilisation using the high factors from the table, which result in cities have the greatest quantum of spare usable capacity, and hence greater ability to support future growth without infrastructure investment;
- The **orange** bars show the normalised utilisation using the low factors, which result in cities have a lesser quantum of spare usable capacity, and hence a reduced ability to support future growth.

3.11 Typically utilisation is greatest in the largest cities, in particular Birmingham, Leeds and Manchester, which reflects these cities relatively high levels of highway congestion and busier, more crowded bus and rail networks. Newcastle and Liverpool are outliers compared to the other large cities, with a greater scale of 'spare' capacity. Broadly, utilisation is lower within small and medium-sized cities, although Norwich is a clear outlier in this regard.

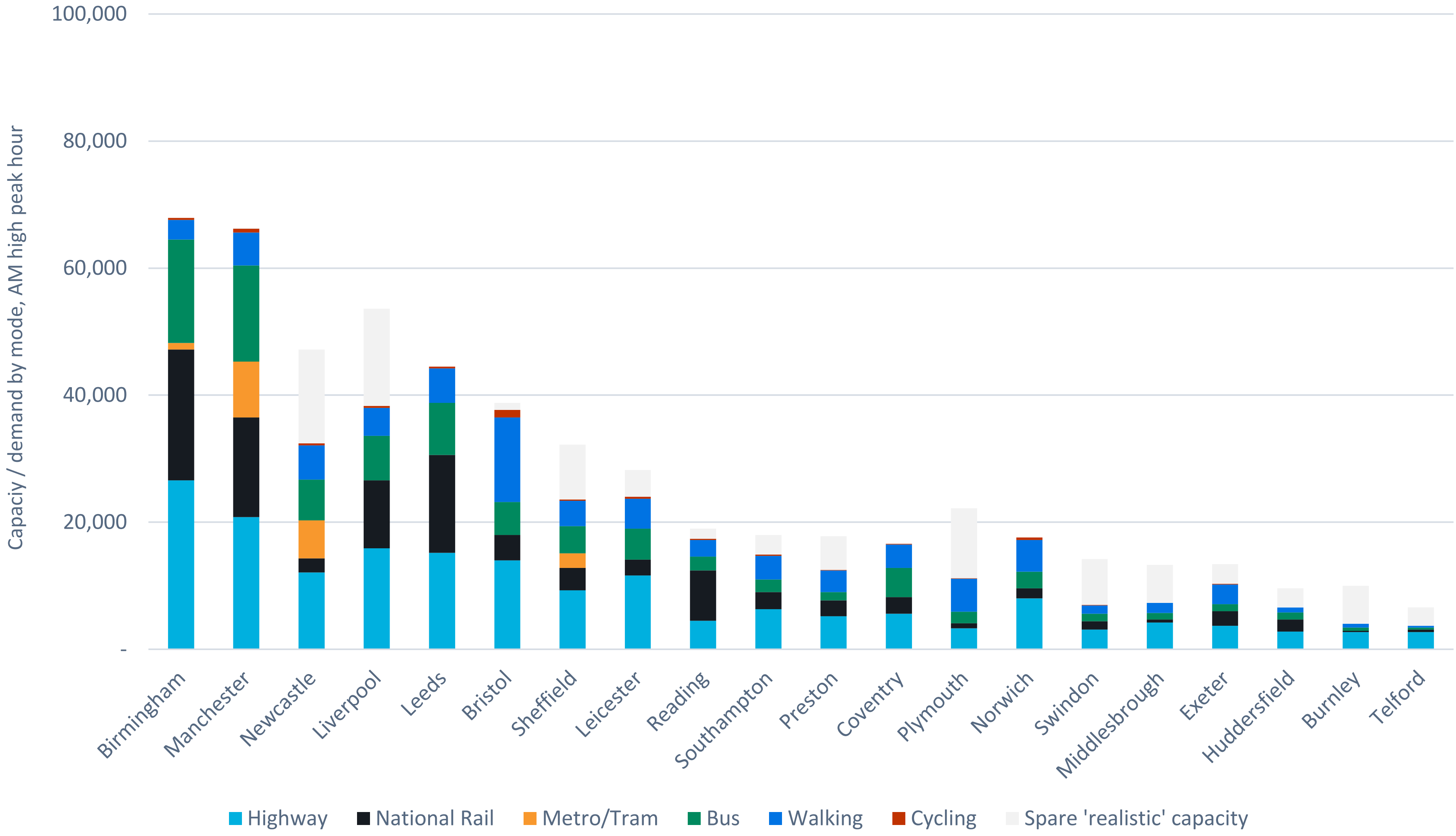
Figure 3.2: Normalised utilisation, by city



3.12 Any city with a normalised utilisation of greater than 100% is subsequently assumed within the analysis to have no spare capacity to support employment growth. The low factors are viewed as a better indicator of the scale of available capacity when benchmarked against other evidence, and were therefore adopted for the remainder of the analysis, with the high factors used as a sensitivity. It should be highlighted that, irrespective of what factors are used, Leeds, Birmingham and Norwich have no spare capacity; the decision of which factors were adopted is more material for cities which are approaching, but not at, 100% utilisation. The choice of factor is not relevant for the majority of smaller cities, which have significant spare capacity irrespective of what factors are adopted.

3.13 Adopting on the low factors, Figure 3.3 shows the same graph as Figure 3.1, but instead the grey represents the spare realistic transport capacity after normalisation. The scale of spare capacity available to support employment growth is significantly reduced, and indeed several cities – Birmingham, Manchester, Leeds, Coventry and Norwich – have no or virtually no spare realistic capacity at all to accommodate future employment growth.

Figure 3.3: AM high peak hour demand and spare 'realistic' capacity across each city centre cordon, 2018 estimated



Potential ability of different cities to support future commuting and employment growth

Approach

3.14 Our approach assumes that AM peak hour demand, normalised capacity and therefore the normalised utilisation of each city **directly informs** the scale of employment growth that each can support without further transport investment. It assumes that:

- Where the normalised utilisation of a city is below 100%, there is spare capacity for employment growth. Growth in commuting and employment can increase up to 100% utilisation **without** transport capital investment; but
- No further commuting growth – and hence employment growth – can occur when normalised utilisation reaches 100%;
- At this point, employment is assumed to be 'capped', leading to a difference between 'unconstrained' and 'constrained' employment growth. The modelling then estimates:
    i. The number of 'lost jobs' – how many jobs within each city's underlying employment forecast cannot be supported by the transport network;
    ii. Each city's transport 'capacity gap' – how much additional transport capacity is required to deliver a city's unconstrained employment growth, and reduce the lost jobs figure to zero.

3.15 This is a **simplification** of the relationship between employment growth and transport capacity constraints, but one considered appropriate for the study. Transport capacity will act as a 'flexible' rather than 'fixed' constraint in practice (discussed in Chapter 2 Para 2.13 and 2.14), in part since the willingness of individuals to justify high levels of crowding to travel to work will vary based on their personal circumstances.

3.16 But over the long term, cities cannot grow beyond what their transport systems can realistically support, and our approach is intended to provide an order of magnitude estimate for the scale of this constraint over time. A more detailed rationale behind this approach, and the simplifying assumptions, are set out in the Methodology Report.

Findings

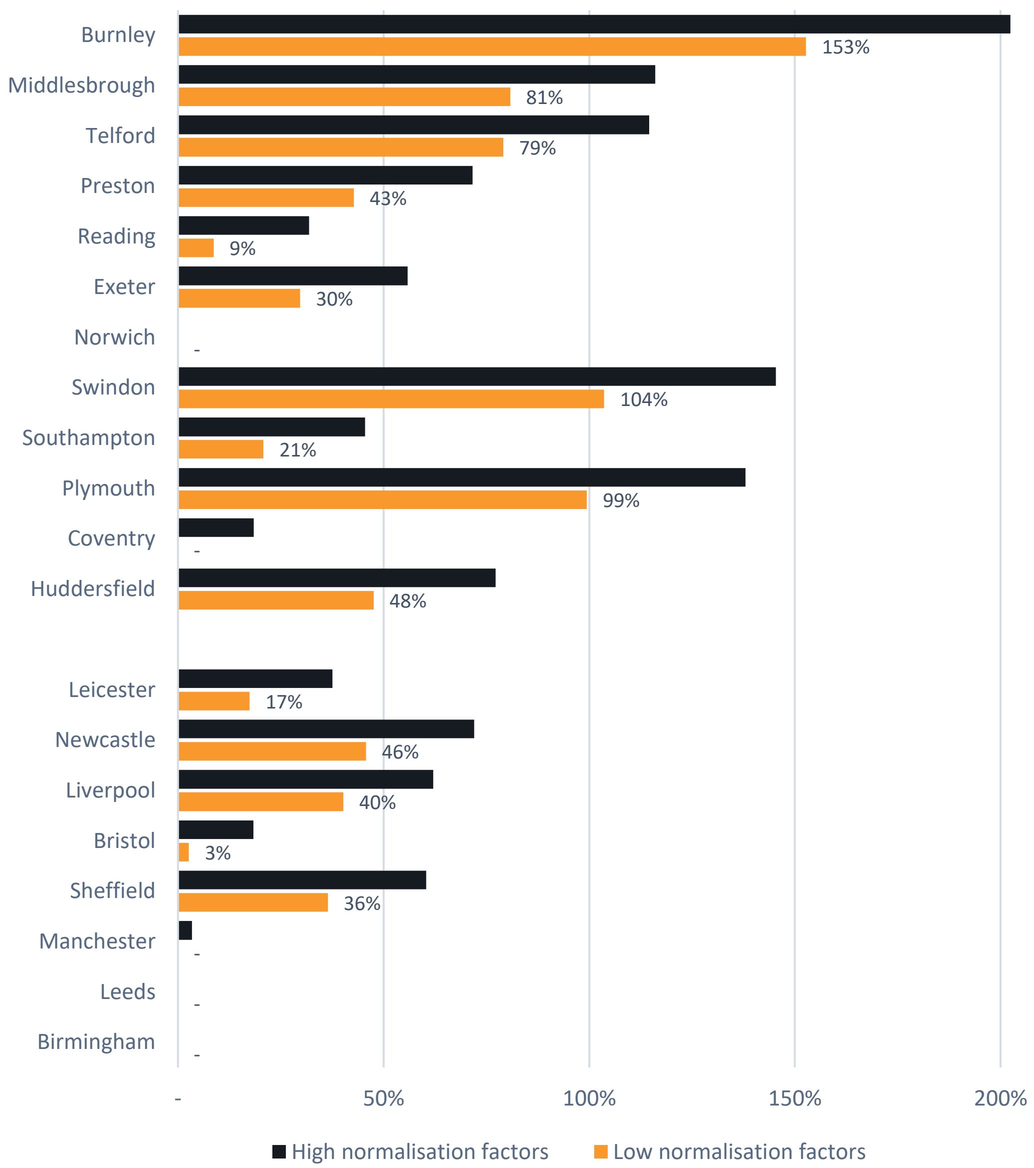
3.17 Figure 3.4 presents the scale of increase in commuting demand that the transport network of each case study city can accommodate, based on the demand, capacity and utilisation analysis. This is underpinned by two further assumptions:

- Commuting demand increases in equal proportion with demand for other trip purposes – such that the overall journey purpose split for cities remains constant over time. For example, a 5% increase in employment will, all else constant, result in a 5% increase in commuting trips (in the baseline), and a 5% increase in other trip purposes (shopping, business, etc);
- Since walking and cycling is not typically constrained by capacity or infrastructure limitations, demand for active modes is allowed to increase within the modelling in line with employment growth, while keeping the mode share for active modes constant compared to 2018.

3.18 This is again shown using the low normalisation factors (in **orange** – adopted for the study) and the high factors (in **black** – used as a sensitivity). This highlights:

- In the baseline, Birmingham, Leeds, Norwich, Manchester and Coventry cannot accommodate any further increase in commuting demand, and consequently employment growth. This is true for the first three cities irrespective of what factors are used for the study;
- Most small and medium cities can accommodate large increases in commuting (>50%), although Norwich is the clear exception.

Figure 3.4: Estimated ability of each city to accommodate employment growth relative to 2018, baseline



3.19 These figures **directly determine the extent to which employment growth is constrained**. If forecast unconstrained employment growth is greater than the percentages shown, then not all growth can be accommodated by the transport network, and employment will be constrained.

3.20 Note that the figure shows the baseline position before the future demand scenarios and uncertainties are applied. In effect, it represents how much commuting growth could be accommodated if the pandemic had not occurred, and if commuting continued to increase in line with historical employment growth. Trends such as increased homeworking, however, may mean that city centres are able to accommodate more employment growth without further investment. This is assessed through the demand scenarios set out in Chapter 4.

4 Exploring future urban, city centre transport demand

Introduction

4.1 Chapter 1 summarised the pre-pandemic position – how much spare transport capacity could support employment growth in each city centre, **before** accounting for trends such as increased homeworking. Greater levels of hybrid and remote working will, for example, result in fewer commuting trips per job, but also raises the possibility for city centres to support more employment growth than they would other otherwise be able to do so (because employment space and aggregate transport capacity over the working week has the potential to be used by more individuals).

4.2 This Chapter considers how a range of uncertainties could alter future commuting demand to 2055, and hence result in different future capacity requirements for urban transport networks. These uncertainties are:

- **future levels of employment growth**, and the extent to which that growth occurs in city centres;
- **future uptake of hybrid and remote working**, and how the days at which individuals work at home are spread across the week (temporal effects);
- the extent to which **businesses centralise in city centres** in response to a fall in aggregate city-wide demand for workspace;
- the extent to which **households move to more suburban locations**, and people commute longer distances to city centres, in response to a reduced need to be physically present at workplaces;
- how the **uptake of connected and autonomous vehicles** could increase the capacity of the highway network, and hence mean the same volume of road space can support higher demand.

Historical and potential city centre employment growth

4.3 Since city centres represent only circa 5% of national employment,[9] trends in city centre employment are strongly dependent on not simply national economic performance, but also the extent to which jobs tend to centralise or disperse within city centres over time. A strong centralisation trend (as experienced in recent decades) or dispersal trend (as experienced in many large city centres from the 1950s to 1980s) can result in the level of city centre employment growth being materially different from that nationally, as well as that of the wider urban areas within which they sit. The role of agglomeration in determining business

[9] Total employment within the city centres of the 54 largest towns and cities in England outside London was approximately 1.4 million in 2018, compared to total employment in England of 28 million.

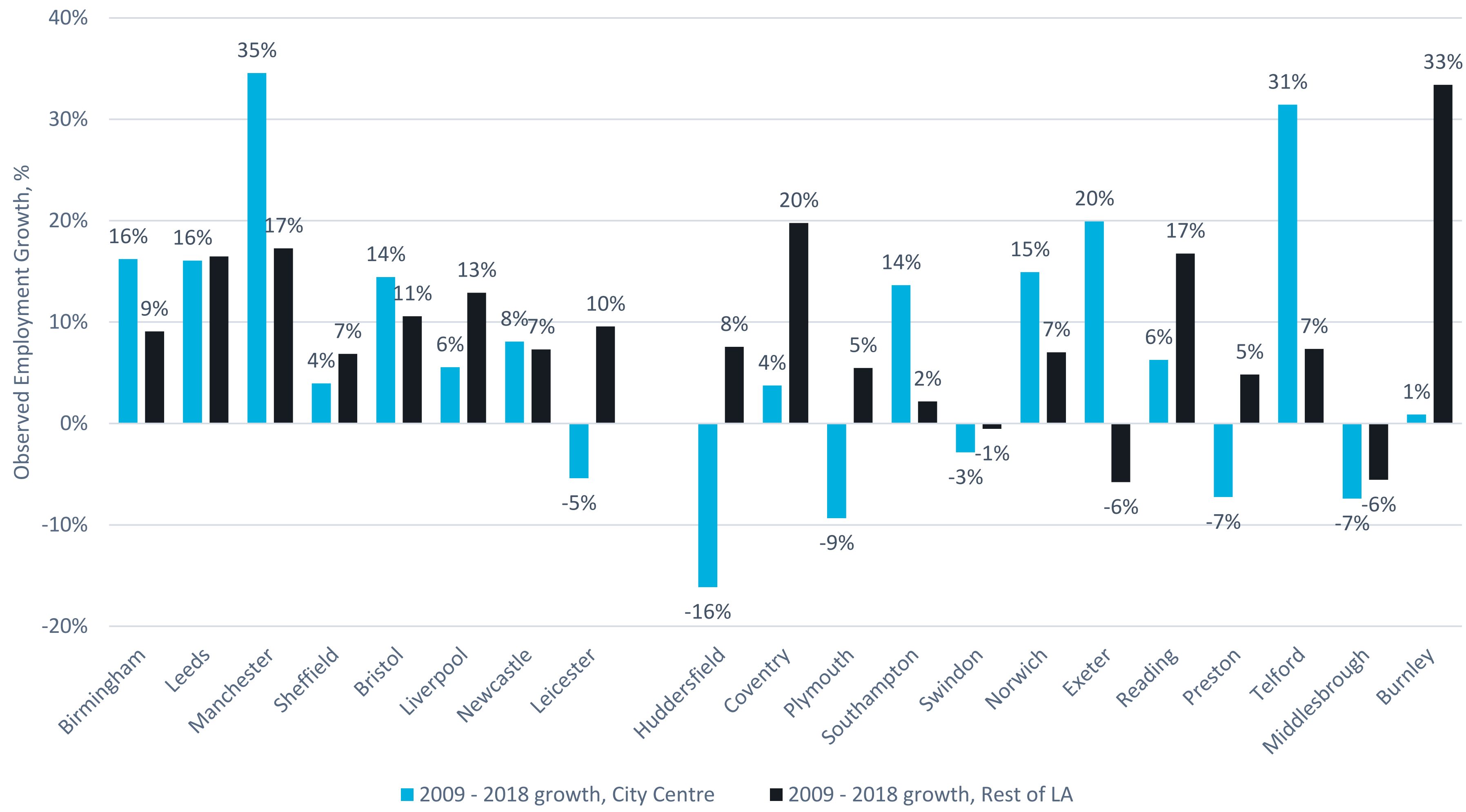
location, and the relative attractiveness of different types of location for different industries (e.g. urban city centre versus suburbs) influence these trends.

4.4 Figure 4.1 presents observed employment growth within each of the 20 case study cities, for both their city centres and the rest of the local authority area for each. Cities are ordered left to right in terms of total employment within each city centre cordon.

4.5 It highlights how, within the larger cities, **city centre employment growth** has **outpaced** that within the rest of the local authority in question. This points to a clear **centralisation** effect for employment within these cities, where employment growth within the city centre is greater than both the rest of the local authority, metropolitan area and/or national average. Average 2009 to 2021 employment growth within the city centres of the large cities is 22%, greater than both the rest of the local authority area for each (16% average), and the national average (14%).

4.6 However, within small and medium cities, there is no discernible pattern. Overall, the 2009 to 2021 period growth is similar within city centres (10%) to elsewhere in the local authority (11%), although reflecting local economic factors, there is significant variation between cities.

Figure 4.1: Observed employment growth, 2009 – 2021, city centres versus rest of local authority



Source: Business Register and Employment Survey

4.7 The implication of this is that if this centralisation trend continues, applying national employment projections may materially underestimate the potential scale of future city centre employment growth. However, especially in light of the pandemic and long-term changes in working practices, it is unclear the extent to which this centralisation effect will continue in future.

4.8 This is an uncertainty captured within our different scenarios, and integral to understanding why future urban capacity requirements differ materially between them.

Future Demand Scenarios

Overview

4.9 Recognising these uncertainties, eight scenarios were developed to assess future capacity requirements in a range of alternative futures for how city centres could grow and evolve to 2055.[10] These are based on two key drivers:

- **Trends in homeworking** – increased adoption of remote and hybrid working is one of the most disruptive impacts of the pandemic, with long-term consequences for both travel demand into cities, and the potential role of city centres in future;
- **Role of agglomeration** – partly (but not entirely) a result of homeworking, a change in the importance of how the agglomeration benefit (the productivity advantages to firms, and especially knowledge-intensive firms) of locating in close proximity to one another and their workers will shape the extent to which businesses choose to centralise in city centres in future, and hence the scale of future employment growth.

4.10 These trends also inform the scale of employment growth assumed to 2055 in city centres, which varies between the scenarios. While overall national employment growth is **comparable** across all scenarios (in line with the ONS National Population Projection – NPP), there are **material differences** within the scenarios regarding the scale of growth that occurs within both city regions, the extent to which it is concentrated in city centres, and more widely the future role of agglomeration within cities.

[10] These scenarios were developed collaboratively between the NIC and Steer, with the broad definition of the scenarios specified by the NIC and technical implementation undertaken by Steer.

4.11 Table 4.1 summarises the employment projections adopted within the analysis. Further detail with how they are derived is provided in the Methodology Report.

Table 4.1: Employment projections adopted within analysis

Employment Projection	Level of employment growth assumed >>			Description
	National	City region / local authority	City centre	
High *ONS High Urban; high re-allocation to city centres*[11]	✓	✓✓✓	✓✓✓	High levels of growth within both our study cities versus the rest of the UK, and a higher-than-average proportion of that growth occurring specifically within the city centre cordons. This reflects a broad, pre-pandemic trend, with agglomeration continuing to result in city centre employment growth outpacing that nationally.
Medium *Mean of ONS Central and High Urban, with medium re-allocation*	✓	✓✓	✓✓	Broadly between the high and low projections, with lower city-specific growth and less growth occurring within the city centre cordon (but still more than the national average).
Low *ONS Central, with no re-allocation*	✓	✓	✓	National growth in line with the ONS Central NPP, with growth in city centres broadly in line with that nationally. This assumes a reduced role for agglomeration compared to pre-pandemic, and no further centralisation of employment (but no dispersal away from city centres to elsewhere).

4.12 These projections have a large-scale impact on the scale of future capacity requirements; all else constant, a larger employment forecast will result in a materially greater capacity requirement. The scale of employment growth under each projection, for each case study city, is summarised in Figure 4.2.

4.13 Table 4.2 summarises the eight scenarios used within the assessment.

[11] The text in italics refers to the underlying ONS population projection (High Urban and ONS Central) and the extent to which growth across the wider urban area is 're-allocated' to city centres within our modelling. This mechanism is set out in detail in Table 2.1 and Paragraph 2.23 of the Methodology Report.

Note that the projections consider growth across all urban areas and city centres nationally; differences between the projections at the level of specific cities mean that, for a small number of cities, the 'high' projection is lower than the 'medium' or 'low' (such as Liverpool and Telford). For example, the 'low' projection uses a 2018-based ONS projection for national employment growth, and the 'high' a 2014-based projection when **national** growth was envisaged to be greater, but this does not mean that growth is necessarily greater in the 'high' rather than the 'low' projection for **every** city.

Figure 4.2: Employment projections adopted within scenario analysis

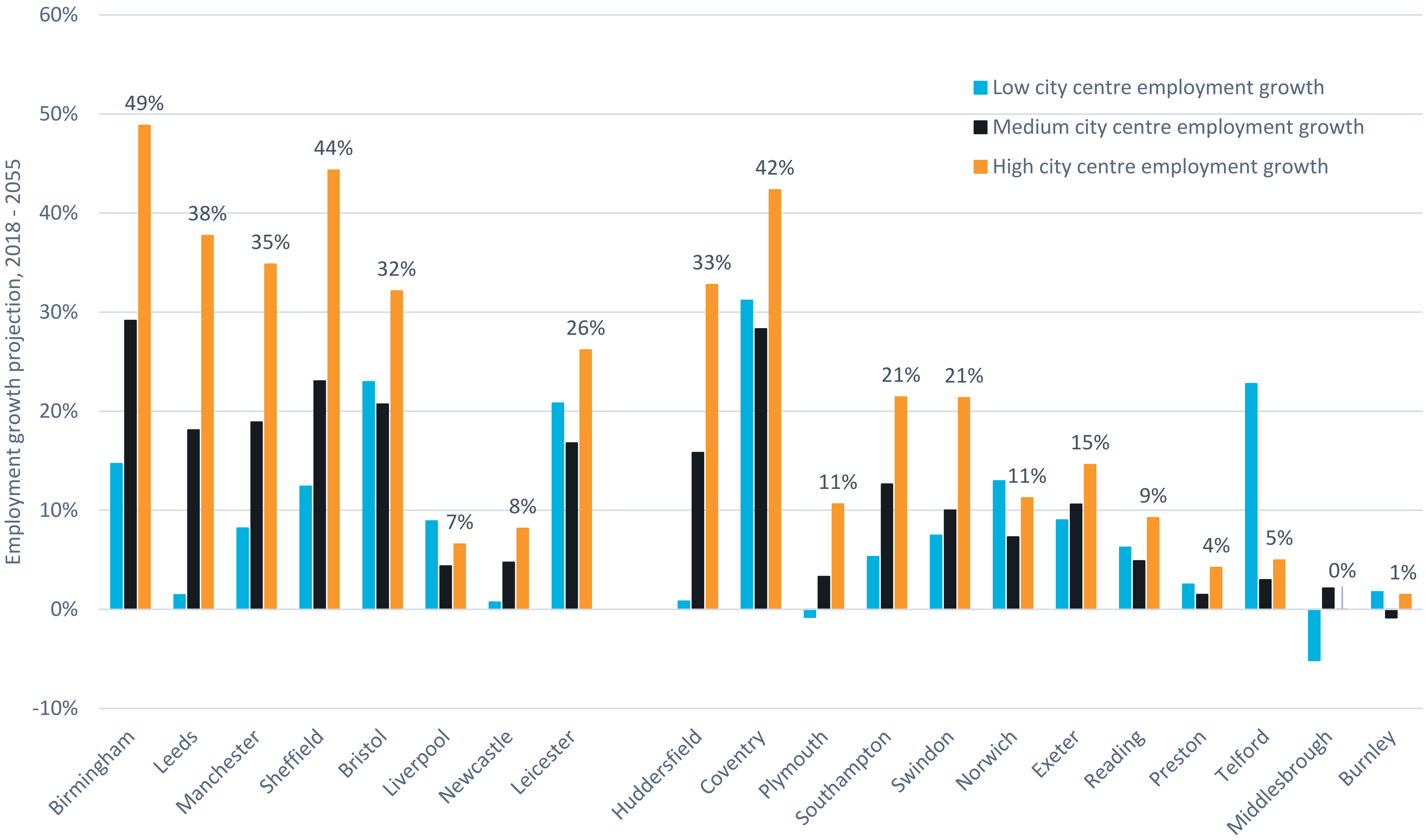


Table 4.2: Summary of proposed 'potential futures' under consideration

Scenario	Description	Levels of hybrid and remote working	Role of agglom-eration	Employment forecast	Temporal effects	Business central-isation	Household suburban-isation	Technology uptake
1 Return to office	Gradual return to pre-Covid trends, with a low uptake of homeworking in the long-term. Employment growth continued to be focused in city centres due to the productivity benefits of increased agglomeration.	✓ (✓) (✓)	✓ ✓ ✓	**High**	**No**	**No effect**	**No effect**	**No effect**
2 City Centre Renaissance	Despite a significant increase in levels of homeworking, due to the continued role of agglomeration, city centres remain the optimal location for many businesses. Businesses previously located in more peripheral locations hence centralise, taking up vacated city centre space due to increased homeworking.	✓ ✓ (✓)	✓ ✓ ✓	**High**	**No**	**High**	**No effect**	**No effect**
3A City Centre Recovery	City-centres remain important business locations, but their competitive advantage is reduced as the role of agglomeration effects decline, in part from a significant increase in levels of homeworking. Compared to #2, this results in: • Lower city centre growth – ONS Central, rather than High Growth; • Medium, rather than High, centralisation effects	✓ ✓ (✓)	✓ ✓ (✓)	**Medium**	**No**	**Medium**	**No effect**	**No effect**
3B City Centre Recovery, with temporal effects	As 3A, but additionally: • Reduced city centre growth reduces office rents, which encourages more 'inefficient' use of space, with more people at a physical place of work Tues/Wed/Thur than Mon/Fri; and • The transport network must cater for high demand on the busiest days, driving investment requirements, but with more 'wasted capacity' on the quieter days	✓ ✓ (✓)	✓ ✓ (✓)	**Medium**	**Yes**	**Medium**	**No effect**	**No effect**

Scenario	Description	Levels of hybrid and remote working	Role of agglom-eration	Employment forecast	Temporal effects	Business central-isation	Household suburban-isation	Technology uptake
3C City Centre Recovery, with suburban-isation	As 3A, except: • There is a greater uptake of homeworking, especially remote working, to broadly the level during the pandemic itself; • This drives suburbanisation effects, as faced with a less frequent commute, individuals can now live further from their place of work	✓ ✓ ✓	✓ ✓ (✓)	**Medium**	**No**	**Medium**	**Yes**	**No effect**
4 Urban Dispersal	There is a large-scale uptake of homeworking, driving increased suburbanisation, and large decline in the role of agglomeration in guiding cities' growth. City centre employment growth is lower, and employment does not 'centralise' in city centres. Cheaper workspace results in 'temporal' effects, as there is less incentive for firms to use their space most efficiently.	✓ ✓ ✓	✓ (✓) (✓)	**Low**	**Yes**	**No effect**	**Yes**	**No effect**
5A Return to Office, with tech	A gradual return to pre-Covid trends, with a low uptake of homeworking in the long-term, and continued city-centre employment growth, but with new technology increasing the capacity of the highway network. As #1, but with technology effects.	✓ (✓) (✓)	✓ ✓ ✓	**High**	**No**	**No effect**	**No effect**	**Yes**
5B City Centre Recovery, with suburban-isation and technology	City-centres remain important business locations, but reduced role of agglomeration reduces city-centre growth and centralisation effects. There is a high uptake of homeworking and associated suburbanisation effects, and new technology increases the capacity of the highway network. As #3C, but with technology effects.	✓ ✓ ✓	✓ ✓ (✓)	**Medium**	**No**	**Medium**	**Yes**	**Yes**

Implications for city centre employment

Approach

4.14 Each of the uncertainties that make up the scenarios result in changes to 'baseline' travel demand, and hence utilisation, as set out in Chapter 1, with limitations for the ability of each city to support future employment growth. Greater levels of hybrid and remote working, for example, result in fewer commuting trips per job, and hence reduces the constraint of transport capacity on future employment growth. The ability for employment to increase before transport constraints are reached varies between the different cities and in different the scenarios, reflecting:

- The different scale of spare 2018 transport capacity;
- The different intensity of the assumptions within the scenarios (e.g. low/medium/high levels of homeworking); and
- Specific characteristics of the cities, and in particular the occupational split of employment within their city centres.

4.15 The extent to which a city’s employment growth is constrained is then dependent on both:

- The ability for transport demand to increase before the adjusted utilisation reaches 100%, after the scenarios are applied;
- The scale of employment growth projected in the scenario.

4.16 If the former is greater than the latter, then city centre employment will not be constrained, and the number of lost jobs for that city is zero. Conversely, if projected employment growth is greater than the ability of transport capacity to accommodate the increase, this is taken to constrain the city’s future employment growth.

Findings and Discussion

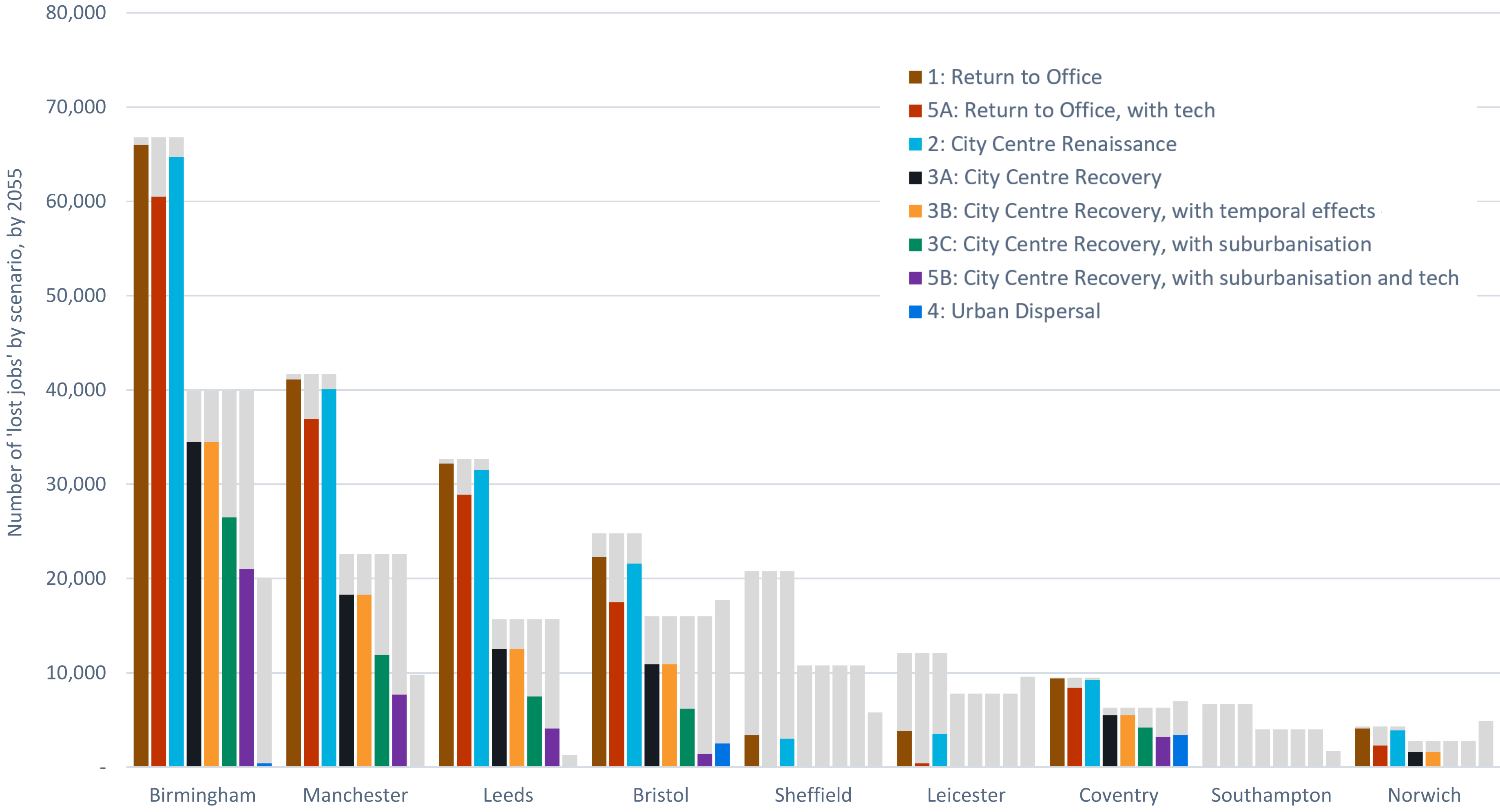
4.17 Based on this approach, and the assumptions for each scenario set out in Table 4.2, Figure 4.3 presents the extent to which by 2055 transport capacity is forecast to constrain city centre employment, under each scenario, for each of the case study cities. Only those cities where employment is forecast to be constrained are shown.

4.18 The **coloured** bars represent the total number of lost jobs within each city for each scenario that the assessment calculates cannot be accommodated because of transport capacity constraints. The **grey** bars behind illustrate the total scale of employment growth projected within that scenario for each city.

4.19 Note that this assumes that employment is constrained by peak hour commuting demand on an ‘average day’ versus capacity, rather than the demand on the busiest, ‘peak day’ if levels of homeworking are not equal across the week (i.e. those scenarios where ‘temporal effects’ apply).

4.20 For example, for Birmingham under the ‘Return to Office’ scenario (Scenario 1 in Table 4.2), 66,000 of the 66,800 additional jobs projected by 2055 cannot be accommodated by the transport network. Conversely, under the ‘Urban Dispersal’ scenario (Scenario 4), only 400 of the 20,500 additional jobs cannot be accommodated. The number of lost jobs is smaller than in the ‘Return to Office’ scenario since the underlying employment projection is smaller and due to increased levels of homeworking freeing up transport capacity which can be used to support greater employment growth.

Figure 4.3: Potential impact on employment of transport constraints, by 2055, by scenario



4.21 The graph clearly highlights how:

- Even in the scenario with the greatest travel demand (Scenario 1 Return to the Office), which assumes a return to pre-pandemic trends, employment is only lost as a result of transport constraints in 10 of the 20 case study cities;
- The distribution of jobs lost as a result of transport constraints is concentrated within the largest cities. The only small city where employment is lost is Norwich.

4.22 However, since employment growth is typically focused within the larger cities – especially those with significant capacity constraints – the aggregate scale of lost jobs across the case study cities is substantial, both in absolute terms and as a percentage of projected employment growth. Table 4.3 presents the total scale of lost jobs, across both the 20 case study cities and all 54 study cities, relative to the projected unconstrained employment growth in each scenario.

Table 4.3: Effect of capacity constraints on city centre employment growth, 2018 to 2055

Scenario	Total 'unconstrained' employment growth, 2018 – 2055		Estimated 'lost jobs' due to transport capacity constraints		% of employment growth estimated to be 'lost' due to capacity constraints	
	20 case study cities	54 study cities	*20 case study cities*	54 study cities	*20 case study cities*	54 study cities
1: Return to Office	247,000	407,000	183,000	274,000	74%	67%
2: City Centre Renaissance	247,000	407,000	177,000	266,000	72%	65%
3A: City Centre Recovery	141,000	233,000	83,000	126,000	59%	54%
3B: City Centre Recovery, with temporal effects	141,000	233,000	83,000	126,000	59%	54%
3C: City Centre Recovery, with suburbanisation	141,000	233,000	56,000	81,000	51%	35%
4: Urban Dispersal	92,000	170,000	6,000	12,000	7%	7%
5A: Return to Office, with tech	247,000	407,000	155,000	229,000	63%	56%
5B: City Centre Recovery, with suburbanisation and tech	141,000	233,000	37,000	54,000	37%	23%

4.23 Even in the most pessimistic scenario for future growth in city centres, and with high levels of homeworking, 7% of city centre employment growth is lost as a result of transport capacity constraints – rising to circa 70% for the Return to Office scenario where city centre employment growth is substantially greater.

4.24 Focusing on the 20 study cities, considering 2018 city centre employment was circa 917,000, the scale of lost jobs – of up to 183,000 – is significant. In the 'Return to Office' scenario, the modelling indicates that total city centre employment would be 17% lower as a result of transport capacity constraints than would otherwise be the case. For some specific cities, this is greater – employment within Birmingham and Manchester, for example, is 33% and 25% lower respectively than would occur without transport capacity constraints.

Implications for transport capacity requirements

Findings and Discussion

4.25 Figure 4.4 summarises the total transport capacity requirement for each city centre, for each scenario, by 2055. For the AM high peak hour, each bar represents the additional number of people crossing each city centre cordon that the transport network must accommodate in order for employment growth to not be constrained, and for the number of lost jobs to reduce to zero. Only those cities where employment is forecast to be constrained are shown.

4.26 The broad pattern of the graph is similar to Figure 4.4, which shows the scale of lost jobs within each city. This reflects how the cities where employment is most constrained (i.e. those with the greater number of lost jobs), have the greatest requirement for additional capacity. As a consequence, the greatest requirements are typically focused within the largest cities; only 10 of the cities have a requirement for additional transport capacity.

4.27 The dotted, higher bars show for those scenarios with temporal effects the transport requirement on a peak day, and how it is materially greater than on an average day (the solid bars). This is notably so for the 'Urban Dispersal' scenario, where temporal effects are applied to a high homeworking assumption. The implication of this is that, on a peak day on which all hybrid workers commute to the workplace, there is a significant capacity requirement – 6,600 in Birmingham and 5,500 in Bristol – compared to a requirement on an average day of just 200 and 1,200 in Birmingham and Bristol respectively.

Understanding differences in capacity requirements between cities

4.28 The transport capacity gap is significantly smaller than the lost jobs presented in Figure 4.3, as new jobs do not result in an AM peak hour inbound trip every weekday – some workers will commute at other times, work-from-home, take leave, etc. However, the analysis does assume that an increase in city centre employment will also increase the number of trips for other purposes (e.g. shopping), such that the journey purpose split of trips entering city centres remains unchanged relative to 2018.

4.29 Additionally, the scale of the capacity gap for each lost job is different for different cities – within Birmingham, 1 job generates 0.5 AM peak hour trips, but this is 0.46 for Norwich. This reflects local circumstances and the ratio between peak demand and employment for each city in 2018. Within some city centres there will be a greater share of non-commuting journeys, for example, if there are large educational institutions within the city centres, or if the city centre is an important interchange for people making trips not to the city centre itself but to onward destinations outside the cordon.

Implications for investment approaches

4.30 The scale of additional capacity shown on Figure 4.4 represents a significant uplift in transport capacity for some cities, particularly in the high scenarios. For example, one Manchester Metrolink line with 10 trams per hour (one every 6 mins), operating double trams, equates to a capacity of circa 4,000 people per hour per direction. In the Return to Office scenario, the capacity requirement for Manchester of 22,700 therefore equates to an additional five to six tram lines, which is similar to the size of the current Metrolink network, operating at 100% of its theoretical capacity.

4.31 This is illustrated further in Figure 4.5, which rather than expressing the capacity requirement for each city in **absolute** terms, expresses it as a **percentage** of the transport capacity provided in 2018. In the three highest scenarios, in Manchester, Leeds, Bristol and Coventry there is a requirement for circa 20% extra capacity; for the City Centre Recovery scenarios, the figure is in the 5 – 10% range.

4.32 It is these requirements that inform the low, medium and high transport investment requirements, discussed in Chapter 5.

Figure 4.4: Urban transport capacity requirements, by 2055, by scenario

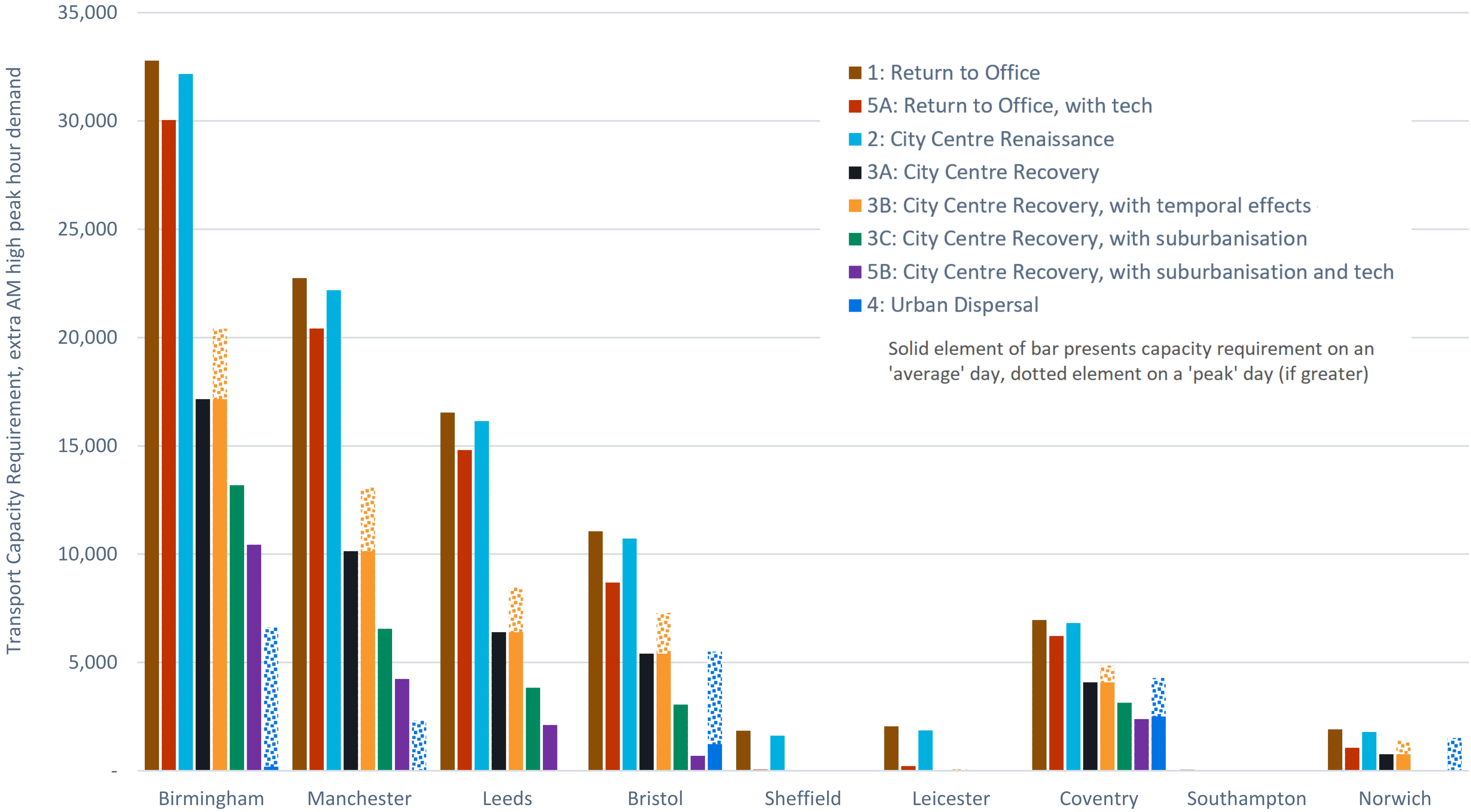
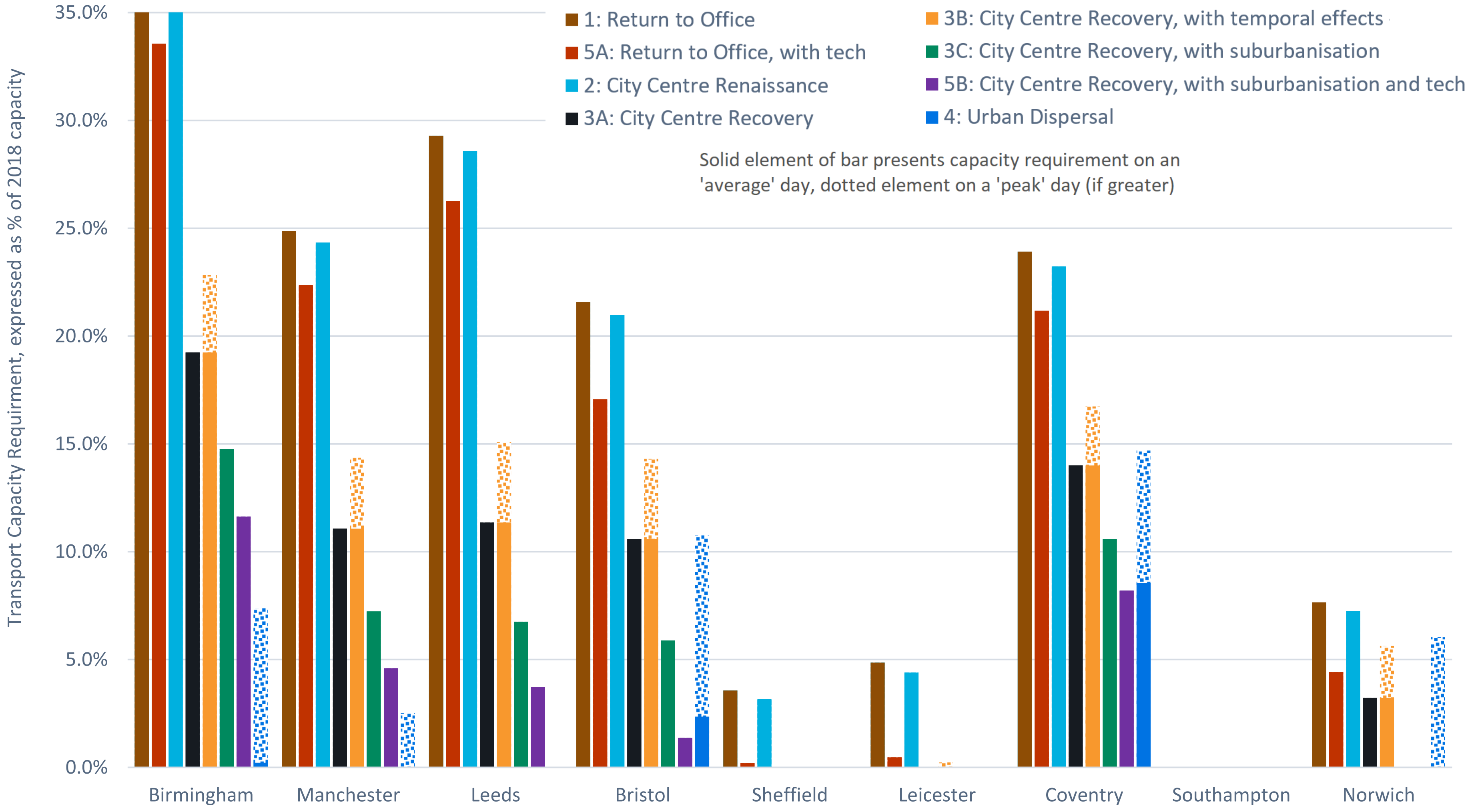


Figure 4.5: Urban transport capacity requirement, by 2055, by scenario – expressed as percentage of 2018 transport capacity



Implications for commuting distances and mode requirements

Background and Approach

4.33 Figure 4.4 and Figure 4.5 present the requirements for city centre capacity, defined narrowly in terms of the number of people crossing each city centre cordon. Within each city, the split of capacity and demand for each mode is different, reflecting both the size of the city and its commuting catchment, and the historical growth in its transport network.

4.34 However, the future requirements on the network will vary based on the geography over which commuting demand occurs. While this is difficult to capture without specific land-use modelling, we have sought to explore the implications for total commuting distance travelled, and modal requirements, by examining the travel behaviour of different Output Area Classification (OAC) supergroups. The OAC is a geodemographic segmentation based on 2011 Census data, developed by the Office of National Statistics (ONS) to better categorise local communities based on their socio-demographics.

4.35 Each group (named by the ONS, and identified in *italics*) has distinct travel behaviours and geographical locations,[12] and they form a framework for considering how suburbanisation effects could change city centre travel demand within cities. If suburbanisation effects occur, we would expect the proportion of the population living within the groups concentrated within inner city locations (*Cosmopolitans*[13] and *Ethnicity Central*[14]) to decline and the proportion of groups who reside in more suburban locations, typically in larger dwellings with gardens (*Urbanites*[15] and *Suburbanites*[16]) to increase. If individuals change group, but continue to commute to the same job within a city centre, this will have implications for transport demand.

Travel behaviours of different groups

4.36 Figure 4.6 presents the commuting distances **to city centres only**[17] by OAC super group, for all cities, groups of cities ('very large', 'large, 'medium' and 'small') and all cities combined. The focus here is on the four super groups involved in the suburbanisation effect – shown in **red**, blue, **black** and **orange**. The size of the bubbles illustrates the relative proportion of the population of each supergroup, in each city, in relation to each other.

4.37 In general, *Cosmopolitans* and *Ethnicity Central* workers tend to commute from locations closer to the city centres (between 2 and 4 miles) than *Urbanites* (around 8 miles) and

[12] An online map of OAC groups can be found here: CDRC Mapmaker: Output Area Classification

[13] *Cosmopolitans* characterise typically young professionals and students, living in dense housing (typically private-rented flats) in inner-city locations.

[14] *Ethnicity Central* characterise young, ethnically diverse households, often with children, typically living in flats within dense inner-city areas.

[15] *Urbanites* characterise households typically within the 'inner suburbs' of towns and cities, with an above-average proportion of private renters in terraces and flats.

[16] *Suburbanites* characterise households on the suburban outskirts of towns and cities, typically living in detached and semi-housing, with high qualifications and levels of car ownership.

[17] This is different to the commuting behaviour of each group nationally – for example nationally the mode share for rail will be much smaller, as rail commuting is concentrated to and from city centre locations.

Suburbanites (9 –to 10 miles). While the exact figures vary between cities, reflecting local geography, the pattern is consistent throughout. Should an individual who retains the same city centre job but changes their location from living in a *Cosmopolitans* to a *Suburbanites* output area, one would expect to see their commuting distance increase more than three-fold.

4.38 Given that the suburbanisation effect, as defined for this analysis, would move population from the *Cosmopolitans* and *Ethnicity Central* groups to *Urbanites*, and *Urbanites* to *Suburbanites*, it is expected that average commuting distances would increase, as workers would move to groups with longer commutes.

4.39 Based on analysis of 2011 Census journey-to-work data, Figure 4.7 presents the estimated mode share for each OAC group commuting **to city centres only**. Since mode share is strongly correlated with distance, there are very material differences between each group. Only 5% of *Cosmopolitans* commuting to city centres do so by car, for example, compared to more than 60% for *Suburbanites* (and over a far longer distance). Rail commuting is also strongly associated with longer-distance flows to city centres.

Figure 4.6: Average commuting distance (in miles) by OAC supergroup, by city

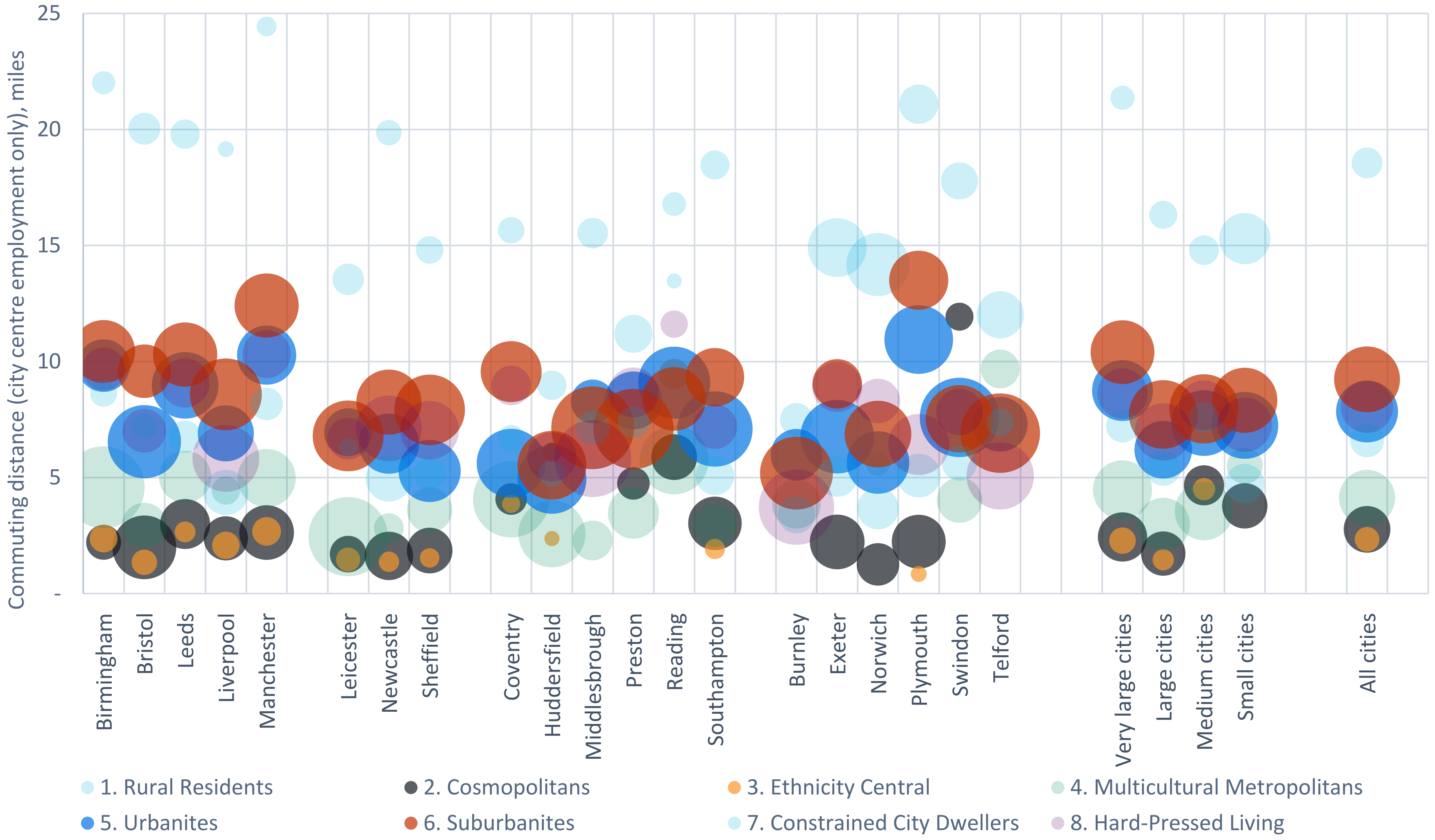
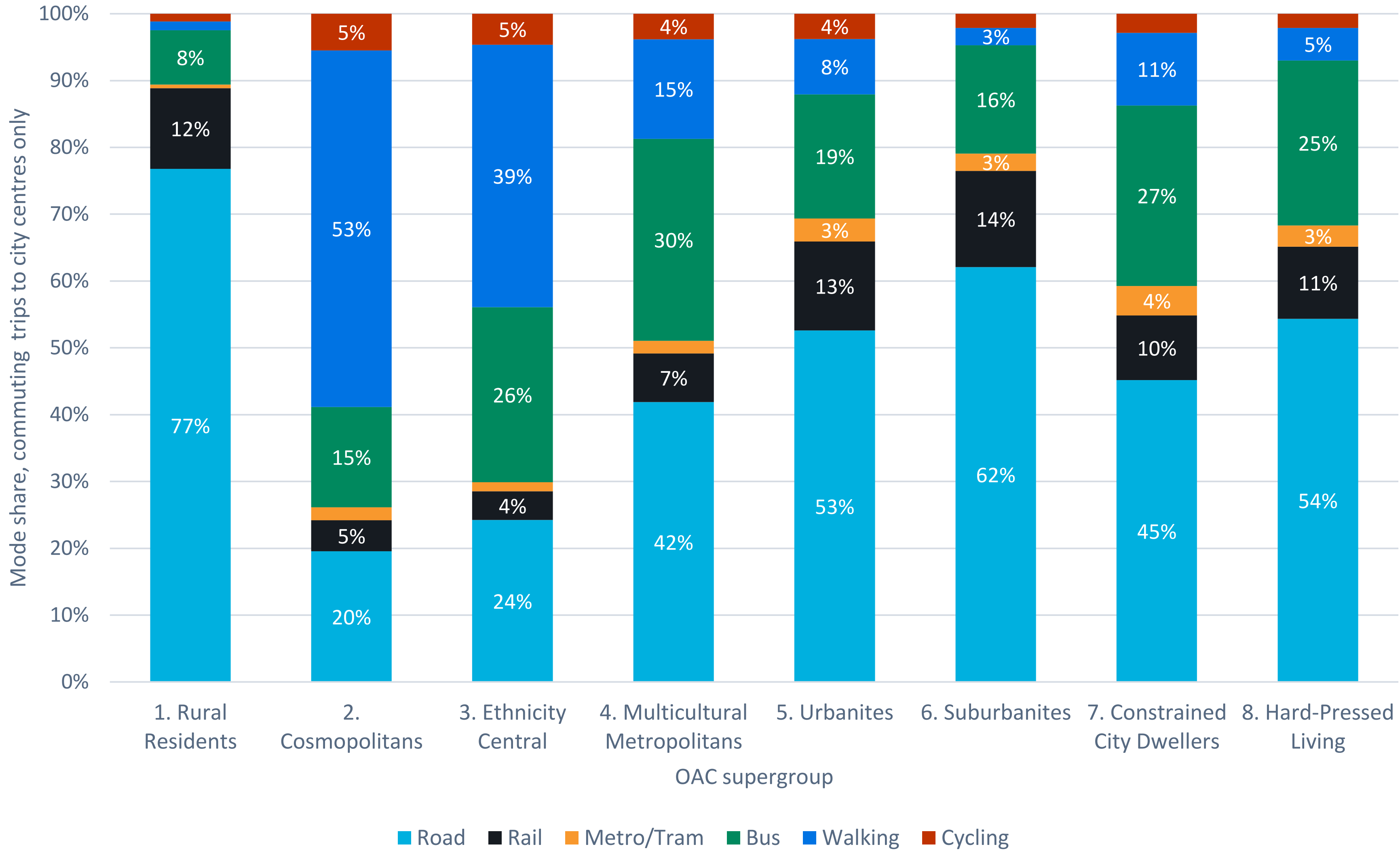


Figure 4.7: Estimated commuting mode share to 20 study city centres, by OAC supergroup



steer

Implications for city centre travel demand and investment approaches

4.40 The implication of this is that any population movement from *Cosmopolitans* and *Ethnicity Central* groups to *Urbanites* and *Suburbanites* will result in:

- an increase in distance travelled (per journey) to city centres;
- based on the current observed mode share of these trips, this would:
    i. significantly reduce the mode share for walking (and cycling);
    ii. slightly reduce the mode share for bus;
    iii. increase the mode share for rail;
    iv. increase the mode share for car (although the distance of these car trips could potentially be shifted to other modes including Park-and-Ride with sufficient investment and/or demand management).

4.41 It is difficult to project or forecast how the population within each group will change in future – this is based not only on other trends such as increased homeworking, but also personal preferences for residential location and dwelling type, and wider planning considerations such as land availability. However, based on the assumptions and approach used for Steer's 2021 research for the NIC exploring behavioural change post-pandemic[18], we have modelled the potential effect of a small but plausible movement from the *Cosmopolitans* and *Ethnicity Central* groups to *Urbanites* and *Suburbanites*, while **maintaining their city centre working locations constant**.

4.42 The results of this are presented in the table below, modelled for each city, based on the outputs of the analysis in Figure 4.6 and Figure 4.7. These occur for the two scenarios where suburbanisation effects occur (3C: City Centre Recovery, with suburbanisation; 4: Urban Dispersal and 5B: City Centre Recovery, with suburbanisation and technology). Note that the percentages for each mode relate to the change in commuting demand for each mode, rather than the percentage point change in mode share (which would be significantly smaller).

4.43 Although, for an individual who changes OAC groups the change in distance and mode is significant (in effect, moving between the bubbles in Figure 4.6 and bars in Figure 4.7) the overall scale of the change on commuting demand by mode in each city is limited. This reflects the small plausible level of change in the population of each group – a largely fixed stock of housing and practical limitations on house building and the planning system will constrain the number who can move in practice. Different patterns of housing stock and different transport options mean that the scale of this effect is also likely to vary between different cities.

[18] Steer (2021) '**Infrastructure Demand Quantitative Analysis for Scenarios of Behaviour Change**'

Table 4.4: Potential effects of suburbanisation on average commuting distance and demand by mode

City	Increase in average commuting distance (%)	Change in commuting demand by mode >>					
		Road	Rail	Metro/ Tram	Bus	Walking	Cycling
Birmingham	0.8%	0.5%	0.8%	0.4%	(0.2%)	(4.5%)	(0.7%)
Bristol	2.4%	2.1%	1.9%	N/A	1.1%	(4.6%)	(1.6%)
Leeds	1.1%	0.9%	0.9%	N/A	(0.3%)	(4.7%)	(1.1%)
Liverpool	0.9%	0.7%	1.0%	0.7%	(0.4%)	(4.1%)	(1.3%)
Manchester	1.6%	1.2%	1.8%	0.7%	(0.8%)	(5.2%)	(1.5%)
Leicester	0.7%	0.6%	0.4%	N/A	0.3%	(2.6%)	(0.3%)
Newcastle	1.0%	0.8%	1.0%	0.1%	0.1%	(3.9%)	(1.1%)
Sheffield	1.0%	0.8%	0.9%	0.3%	0.0%	(3.3%)	(0.8%)
Coventry	0.8%	0.4%	0.1%	N/A	(0.2%)	(1.6%)	(0.5%)
Huddersfield	0.1%	0.1%	(0.5%)	N/A	0.0%	(0.7%)	0.0%
Middlesbrough	0.0%	0.1%	(0.2%)	N/A	0.0%	(0.4%)	(0.1%)
Preston	0.1%	0.3%	(0.3%)	N/A	0.1%	(1.6%)	0.1%
Reading	0.1%	0.9%	0.2%	N/A	0.5%	(2.6%)	(0.1%)
Southampton	1.1%	0.9%	0.8%	N/A	0.1%	(3.1%)	(0.8%)
Burnley	(0.0%)	0.0%	(0.1%)	N/A	0.0%	(0.1%)	0.0%
Exeter	0.9%	0.9%	1.0%	N/A	0.6%	(2.1%)	(0.7%)
Norwich	0.5%	0.6%	0.4%	N/A	0.7%	(2.2%)	(0.5%)
Plymouth	1.2%	0.8%	0.3%	N/A	0.8%	(2.8%)	0.1%
Swindon	(0.1%)	0.2%	(0.6%)	N/A	0.3%	(1.1%)	(0.1%)
Telford	0.1%	0.0%	(0.9%)	N/A	0.0%	0.0%	0.1%
All 24 case study cities	0.7%	0.8%	1.0%	0.3%	(0.0%)	(3.5%)	(0.9%)

4.44 Despite this, there are important implications for investment approaches. Large increases in car demand cannot be accommodated in practice, with therefore a requirement towards more medium and longer-distance public transport capacity. Population movement away from inner city locations towards more suburban ones will reduce the scale of commuting by active modes, with the implication that these individuals will instead need to be accommodated by the public transport system. While this requirement will vary across cities, it is likely to mean:

- a reduced requirement for **local bus** capacity and connectivity;
- an increased requirement for **rail**, especially connectivity to and from small commuter towns and rural hinterlands surrounding large cities (where this can feasibly be provided);
- an increased requirement for **metro, tram and/or high-quality BRT services** that provide journey times and reliability competitive with private car from suburban locations to city centres (typically greater distances than local bus journeys);
- an increased requirement for **park-and-ride connectivity**, and/or **'first-last' mile solutions**, to rail, metro, tram and/or BRT stops and stations.

5 Approaches for increasing urban transport capacity

Introduction

5.1 Chapter 4 explored the potential scale of urban transport capacity requirements considering a range of uncertainties, including future levels of homeworking and city centre employment growth. Figure 4.4 presented a core projection of the scale of capacity requirement, for each city, to 2055 in each of the scenarios considered. This figure represents an estimate of how much additional capacity must be provided across each city centre cordon, in the high peak hour, to avoid future employment growth becoming constrained.

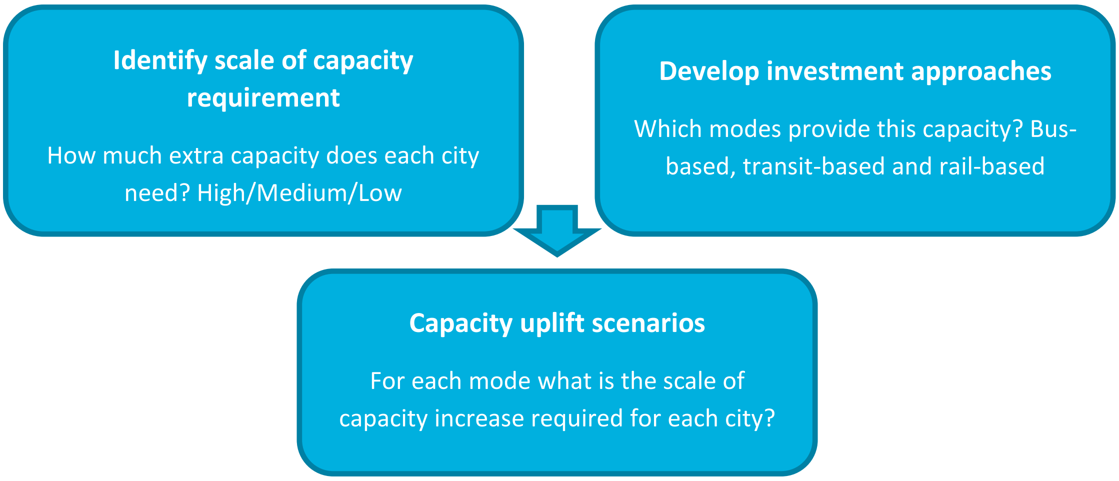
5.2 This Chapter considers different approaches for how that transport capacity could be delivered in practice. Combined with the capacity requirements, it sets out 'capacity uplift scenarios' which form the basis of the capital cost estimate provided in Chapter 6.

Approach

5.3 The broad approach is shown in Figure 5.1. Based on the capacity requirements presented in Chapter 4, we:

- Assume a high, medium and low scale of requirement for each city, based on the scenario analysis presented in Figure 4.2;
- Develop three 'investment approaches', which describe the balance of modes through which this capacity is provided ('bus-based'; 'rail-based'; 'transit-based');
- Based on the combination of the three capacity requirements and three investment approaches, we derive nine 'capacity uplift scenarios', which define both the broad scale of the capacity required and the modes through which it is provided. The assessment is made for each case study city.

Figure 5.1: Approach to Developing Infrastructure and Cost Estimates



Scale of capacity requirement

Approach

5.4 Figure 4.4 presented the scale of urban transport capacity requirement, by 2055, for each city for each scenario, and highlighted that:

- There is a **wide range of future capacity requirements**, both between different cities and in different scenarios – largely due to the uncertainties surrounding future levels of homeworking and city centre employment growth;
- In the high scenarios many of the largest cities have **significant capacity requirements** – Birmingham and Manchester, for example, in the highest scenarios had capacity requirements of greater than 20,000 extra people;
- Conversely, even in the high scenarios, 10 of the 20 case study cities did not have a capacity requirement at all.

5.5 We adopt a low, medium and high-capacity requirement for each city for the remainder of the analysis. These were developed collaboratively with the NIC, with the aim of both:

- effectively capturing the range of uncertainty in future capacity requirements;
- directly linking the capital costings to a specific scenario, with an underlying series of assumptions.

5.6 Table 5.1 summarises the low, medium and high-capacity requirements adopted for each city, and the scenarios they correspond to. They were adopted to simplify the capital cost assessment, costing three specific capacity requirements (from a realistic 'high' to 'low'), rather than each of the scenarios individually. The definition of the high, medium and low should not be interpreted as indicating that these scenarios are more likely to occur than others.

Table 5.1: Capacity requirements assumed for Chapter 3 and 4 analysis

Case Study City	City size	Low capacity requirement *Urban Dispersal scenario*	Medium capacity requirement *City Centre Recovery scenario*	High capacity requirement *City Centre Renaissance scenario*
Birmingham	L	190	17,160	32,160
Manchester	L	-	10,140	22,180
Leeds	L	-	6,390	16,140
Bristol	L	1,230	5,400	10,720
Coventry	M	2,500	4,080	6,820
Leicester	L	-	-	1,860
Norwich	S	20	760	1,790
Sheffield	L	-	-	1,620
Other 12 case study cities		No urban capacity requirement		

Rationale

5.7 The '**high**' capacity requirement has been aligned to Scenario 2: City Centre Renaissance scenario, which projects a renewed role for city centres in a post-pandemic world. While in this scenario homeworking increases, the continued role of agglomeration means that employment continues to centralise in city centres, generating high travel demand. This was adopted as the high as it was felt to be more plausible an outcome than the alternative high scenarios, which were Scenario 1: Return to Office (which assumes low levels of homeworking) and Scenario 4B: Return to Office with tech.

5.8 The '**medium'** requirement has been aligned to Scenario 3A: City Centre Recovery, which projects a continued role for city centres post-pandemic, but where the long-term effect of the pandemic is to reduce the role of agglomeration, leading to fewer businesses centralising in city centres and lower employment growth, which in turn dampens travel demand compared to the Renaissance scenario. This was adopted as the medium requirement as:

- **it represents a plausible central requirement for future urban capacity** considering the likely long-term, negative impact of increased homeworking on travel demand – a significant effect compared to pre-pandemic trends;
- **it does not include temporal effects** in the core capacity requirement – in our view, it is unlikely that major public transport infrastructure enhancements could be justified on the basis of peak day demand occurring on a small number of working days a week; instead, were demand to be poorly distributed across the week, policy measures and/or amended fare structures would be implemented to encourage demand to spread across the week, or there would be an acceptance of higher levels of crowding on the busiest days.

5.9 The '**low'** requirement has been aligned to Scenario 4: Urban Dispersal, which assumes a reduced economic role for city centres in future, with more dispersed growth away from city centres and high levels of homeworking combining to materially reduce travel demand compared to pre-pandemic trends. In this scenario, only a small number of cities have a requirement for additional transport capacity.

5.10 To understand how capacity might be provided, it is necessary to consider the different transport modes which, through future investment, could realistically deliver capacity at the scale required.

Investment Approaches

How should additional transport capacity be provided?

5.11 We have adopted three broad approaches for how additional city centre transport capacity could be practically delivered on the transport network. These are:

- **Bus-based:** Investment in additional bus capacity can offer a low-cost option for meeting future demand, through providing additional buses and bus priority infrastructure. However, there are significant feasibility constraints of a large-scale increase in bus capacity within large cities, which limits the ability for a bus-based approach to provide large capacity increases;
- **Mass transit-based:** Investment in new and expanded light rail and tram networks to provide additional capacity. These systems can run high-frequency, high-capacity services, but at lower cost than heavy rail, with a focus on providing short- to medium-distance capacity and connectivity;
- **Rail-based:** Investment in new and expanded rail infrastructure can deliver high levels of capacity efficiently, typically over medium to long commuting distances. However, major rail capacity enhancements are expensive to implement and may require significant additional infrastructure to integrate additional rail capacity into the existing network.

5.12 While it may be possible to deliver the majority of the required capacity uplift through a single mode, this is unlikely to be the most effective method of delivery. Different modes serve different markets, and cannot be considered entirely interchangeable.

5.13 City centres, by their built-up nature, are also space constrained, and modes vary in terms of their space efficiency, an important consideration in city centres where multiple corridors converge. For example, while a light rail route may only operate with six trams per hour outside the city centre, within the city centre where multiple routes converge, a single length of track can accommodate much higher frequencies.

5.14 While each investment approach seeks to provide the majority of required capacity through a single mode, we assume that each approach still retains a balance of capacity provided through different modes. For example, a bus-based approach does not mean that all capacity is simply provided by bus. Additionally, this balance between modes will not be the same for all city sizes and for all scenarios.

5.15 We therefore assume a specific mode split, for each combination of:

- **Investment approach** – bus-based, mass transit-based or rail-based;
- **City size** – with small cities, medium and large cities without a transit network, and medium and large cities with a transit network, treated independently;[19]
- **Capacity requirement** – low, medium or high.

5.16 Table 5.2 summarises the key assumptions/assertions central to the assumed distribution of capacity across modes in each scenario and city type.

Table 5.2: Key Assumptions for Capacity Distribution by Mode

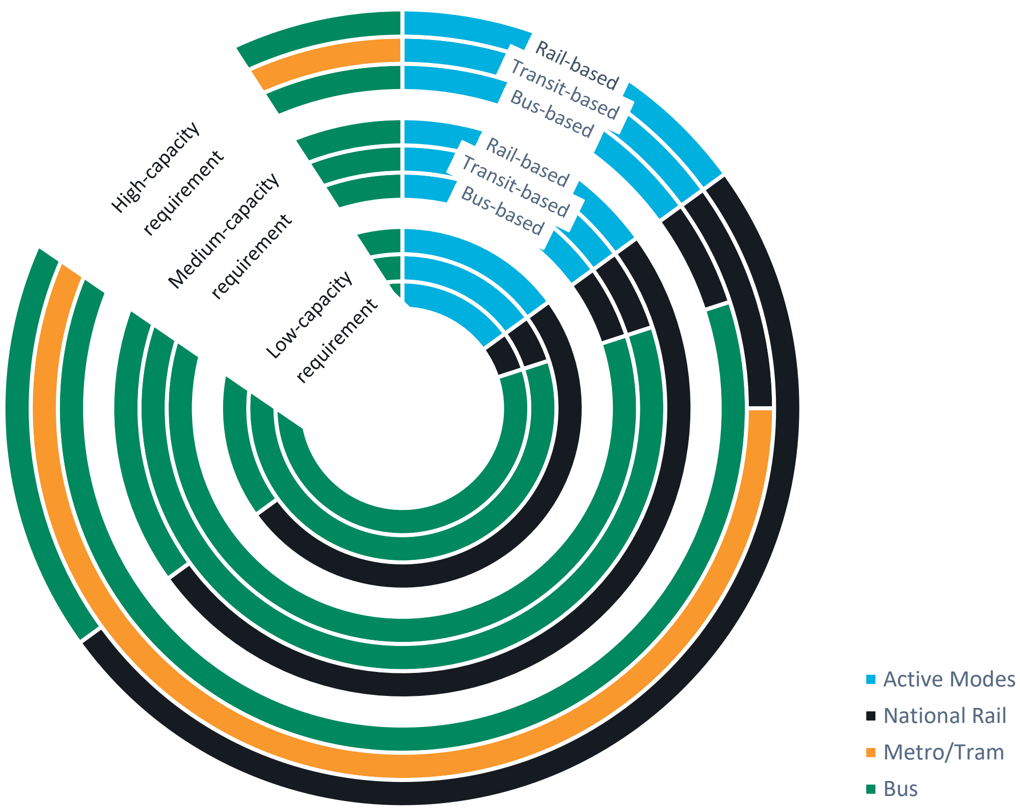
Mode	Assumptions
Bus	• Large cities are likely to experience kerb space constraints within their city centres for providing bus stops. Moreover, in large cities road capacity constraints are likely to affect bus journey times. For these reasons, buses are utilised to a lesser extent in the higher uplift scenarios. • In small and medium-sized cities, it is assumed there is greater ability to accommodate additional bus services. However, medium-sized cities may also need to higher capacity modes (such as light rail) in the higher demand uplift scenarios. • Currently, local authorities have limited ability to influence how bus services are provided, although additional powers are being made available to local decision makers through devolution deals (for capital spend) and some areas are implementing or exploring franchising. Outside London, bus patronage has faced long term downward trends. Therefore, any uplift in bus capacity will likely require additional incentives to drive any marked uptake in utilisation. • Buses are a flexible transport mode. Unlike trams, which require fixed infrastructure on a specified route, bus routes can change over time as origin-destination pairs change.
Light Rail/Tram	• Small and medium-sized cities that do not have an existing light rail/tram system are unlikely to consider construction of a new network unless they have a significant requirement for new capacity.

[19] This reflects how there is an important distinction between increasing metro or tram capacity in cities where there is already a network (ability to lengthen trams or increase frequencies at relatively low capital costs) versus those without (any provision of metro or tram capacity requires new network infrastructure, at significantly higher capital cost).

	• Light rail networks can be expanded incrementally over time, with new lines and more frequent services, more feasibly than rail. Large networks can serve a wide variety of trip origins. • Light rail is generally perceived as a more attractive mode than bus, and more likely to be viewed as a viable mode of commuting than a bus journey, even where the journey time, reliability and trip distance is similar.
Rail	• Rail network coverage is poorer in smaller cities, with only a selection of trip origins served by rail. The contribution of rail to providing capacity increases in small and medium cities, therefore, is lower. • Rail is a national network, not necessarily focused on maximising capacity into each and every case study city. Constraints on the rail network outside of cities may be the limiting factor on the ability to provide additional rail capacity. Light rail is therefore considered a more targeted mode for providing urban transport network capacity in many instances. The importance of rail capacity is greatest in the higher uplift scenarios.
Active Travel	• For the majority of the population, active modes are only attractive for relatively short trips, therefore the market for these modes in this study is limited to people living in close proximity to the city centre. For all scenarios, we have therefore limited the capacity provided by active modes to 15% of the total capacity. • New transport infrastructure generally has provision for active modes, therefore the costs developed account for some investment in active modes.
Road	• Providing capacity through additional road infrastructure has not been considered as part of this study, as it is unlikely to both provide capacity at the required scale across the city cordons, or be deliverable in practical and feasibility terms.

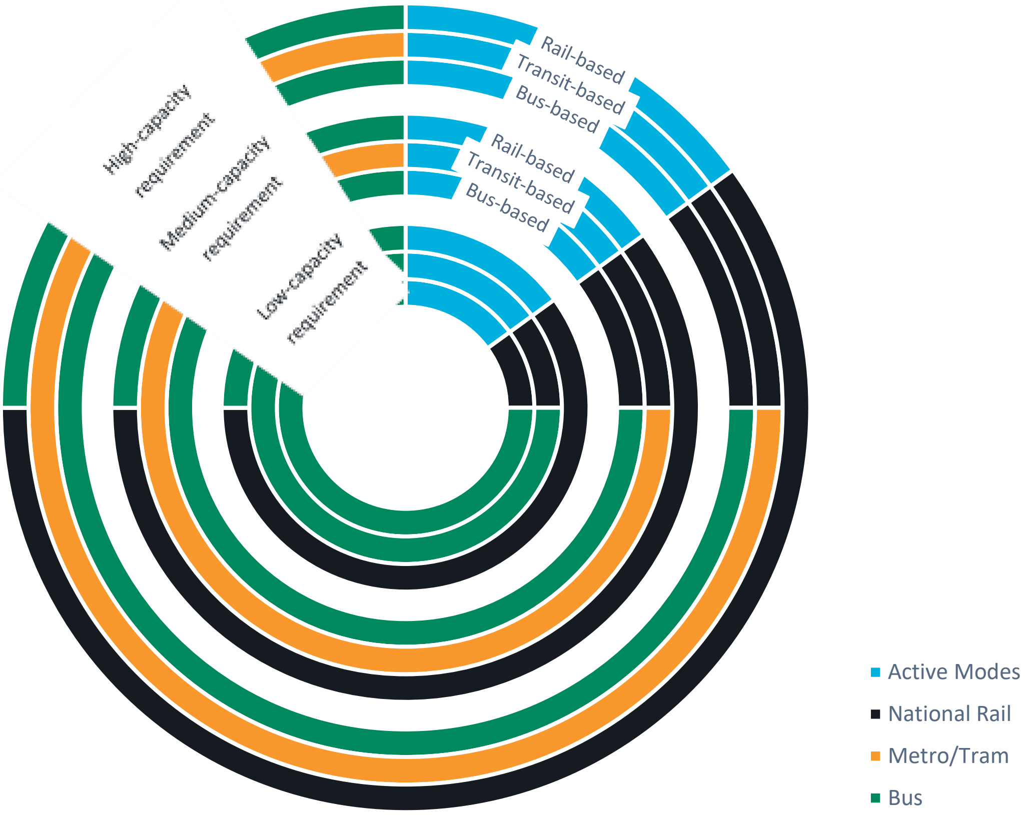
5.17 The detailed investment approaches, for each size of city, are shown in the figures below.

Figure 5.2: Assumed modes capacity is delivered through for a small city



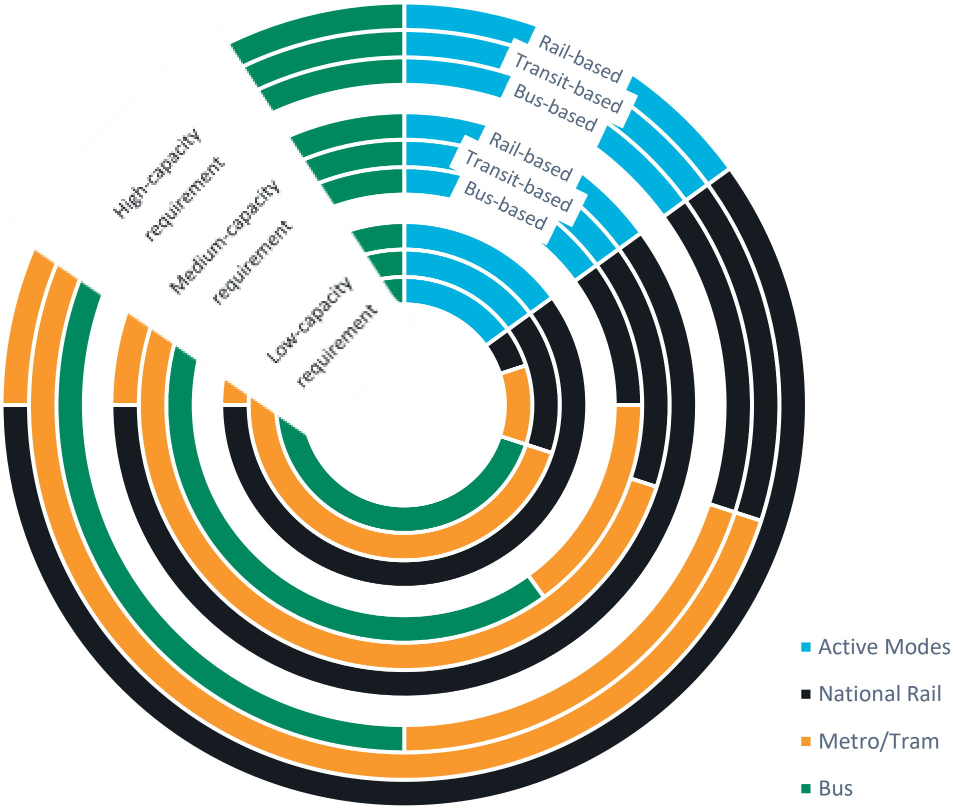
5.18 In small cities, none of which have an existing metro or tram network, the required capacity uplift could mostly be achieved through bus with investment in rail also considered in the rail-based approach. Note it is considered unlikely that a small city would consider a mass-transit investment approach in practice.

Figure 5.3: Assumed modes capacity is delivered through for a medium or large city, without an existing metro or tram network



5.19 Figure 5.3 shows that, for a medium or large city without an existing transit network, capacity requirements can be more equally provided across different modes. If the capacity requirement is high enough, it may be reasonable to consider the construction of a light rail/tram scheme, particularly in cities where bus and rail are already at or close to capacity.

Figure 5.4: Assumed modes capacity is delivered through for a large city, with an existing metro or tram network



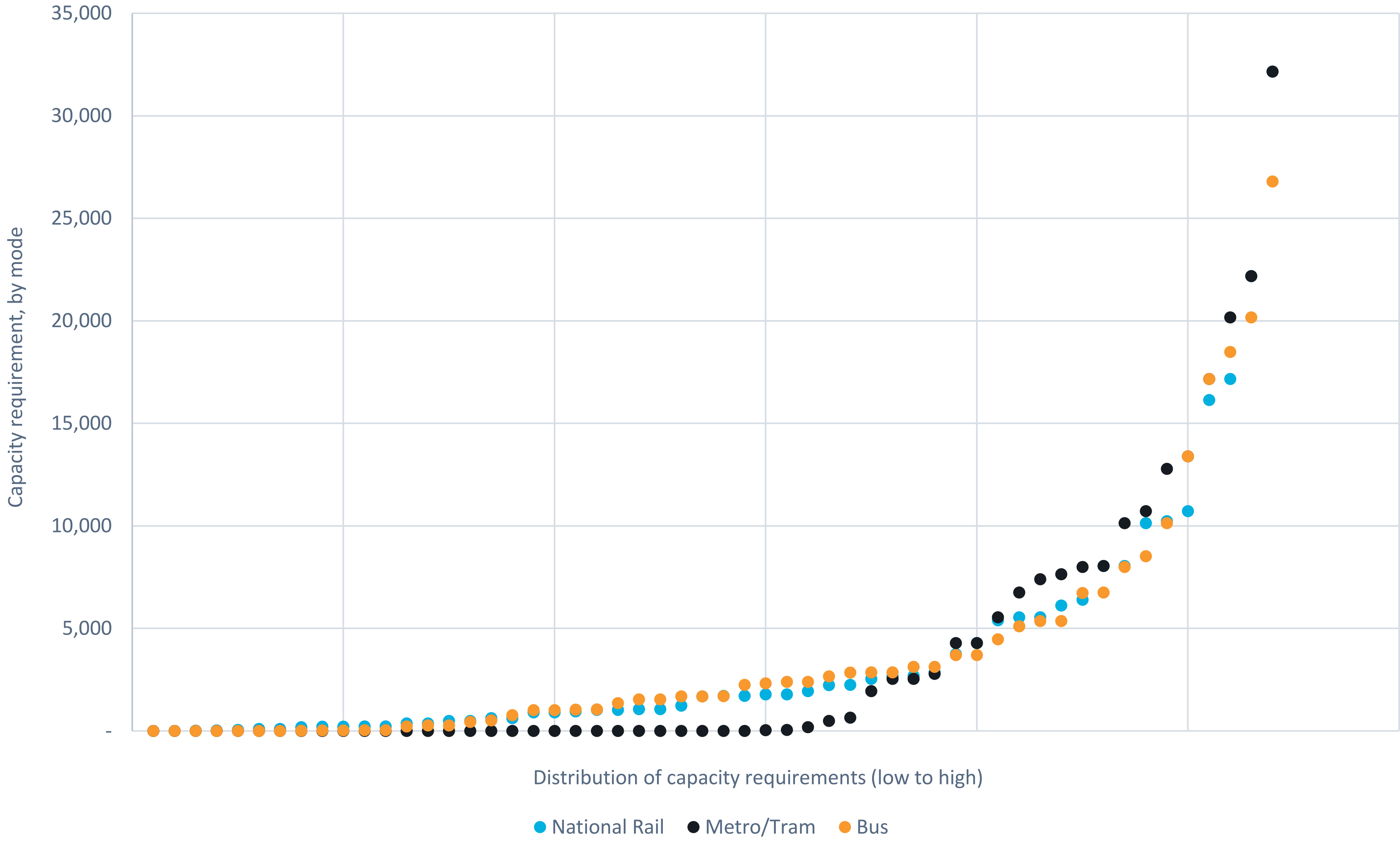
5.20 As shown in Figure 5.4, in large cities with an existing transit network, such as Manchester, constraints with the city centre means that large increases in bus services are unlikely to be a viable option for providing capacity at the scale required, so greater capacity is assumed to be delivered from transit and rail compared to smaller cities.

Capacity Uplift Scenarios

5.21 Combining the specific low, medium and high capacity requirements for each city (shown in Table 5.1) with the different investment approaches (shown in Figure 5.2 to Figure 5.4) generates nine capacity uplift scenarios for each city.

5.22 Across all cities, these express the range of capacity requirements for each mode – in effect, how much additional capacity is required on each mode – which forms the basis for the costing exercise in Chapter 6. The broad range of these requirements, across all cities, is shown in Figure 5.5.

Figure 5.5: Breadth of capacity requirements by mode under different scenario combinations



5.23 Each dot represents the exact capacity requirement, by mode, for a different combination of city, high/medium/low capacity requirement and investment approach. It highlights the broad breadth of requirements that the scenarios generate.

5.24 Generally, capacity requirements for each mode are below 5,000 extra people per hour per direction. However, within a small number of cities, the combination of a high net capacity requirement (across all modes) and specific investment approach directing the majority of required capacity towards a single mode results in a very significant capacity requirement for that mode.

5.25 For example, the top-right black dot represents the mass transit requirement for Birmingham under the combination of a high net capacity requirement and a transit-based investment approach, with a need for additional high-peak hour inbound light rail capacity of circa 32,000 people. This represents a very material level of investment – equivalent to an additional circa 78 double trams crossing the city centre cordon in the peak hour.

Capacity normalisation

5.26 Note that these requirements shown in Figure 5.5 are expressed in terms of theoretical capacity – the total capacity of a specific bus or train length multiplied by the service frequency.

5.27 This is distinct from the normalised, realistic capacity, which represents the capacity that is readily available for use – for example accounting for how some capacity is inevitably lost as it is provided on corridors where it is not required, or where specific services cannot be perfectly matched to the spatial and temporal patterns of demand (as discussed in Chapter 3 Para 3.5). This 'normalised' measure is how the capacity shown in Table 5.1 (and Figure 4.4) is expressed.

5.28 We convert back from 'normalised' capacity to 'theoretical' capacity since, when planning additional infrastructure need, one cannot assume that new capacity provided can be used at 100% efficiency. Increasing the frequency of bus (and tram) services could increase the potential for services to bunch together, meaning total capacity cannot in practice be used, and new tram or rail infrastructure is likely to provide too much capacity on some corridors but not cater fully for demand on others.

6 Potential role of demand management

Introduction

Background and Purpose

6.1 Demand management describes a range of measures that seek to better manage the use of transport capacity, typically through reducing the demand for car trips and consequently:

- reducing traffic congestion, and the negative impacts of congestion on journey times and the local environment;
- releasing capacity (and roadspace) for more efficient modes such public transport and for cycling, including dedicated bus/tram priority or segregated infrastructure, and/or urban realm enhancements;
- contributing to other goals such as meeting net zero; and/or
- raising additional revenue to fund transport capital or operating expenditure.

6.2 However, as highlighted within the NICs' June 2022 *Getting Cities Moving* report[20], the success of such measures is not guaranteed, and is highly context-specific. Through a case study evidence review, and a high-level assessment of the capital and operating costs and revenues of potential demand management approaches, we have sought to:

- assess the potential role of demand management in increasing and/or better managing transport capacity to support city growth;
- assess the role of demand management in encouraging mode shift, and the consequent impacts on capacity requirements within cities;
- discuss the potential role of demand management within the 54 cities as a future policy tool, and the wider benefits versus costs of different demand management approaches;
- understand the potential capital costs, and ongoing revenue impacts, of these different approaches.

6.3 This section discusses the first three of these themes. Capital costs and revenues for different demand management approaches are set out in Chapter 7. It should be highlighted that the evidence that is available and directly transferable to support our assessment is limited, since:

- Within the UK, there is very limited evidence regarding the effects of charging-based approaches. In particular, outside London there is no observed evidence of the impacts of congestion charging, noting that the London Congestion Charge operates in a very

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[20] National Infrastructure Commission (2022) '**Getting Cities Moving: Adaptive transport solutions for an uncertain future**'

different urban environment to other English cities. Even globally, there are very limited examples of where charging has been introduced in medium and smaller-sized cities;

- Much of the evidence only considers short-term, transport impacts of schemes – such as change in demand by mode – and does not consider wider implications such as local economic impacts or changes to patterns of land use.
- Schemes are highly context-specific, and outcomes from one scheme are may not be readily applicable elsewhere. When thinking about overseas examples, consideration also needs to be given to legal, cultural and societal differences as well as economic, land use and transport characteristics.

6.4 With these considerations in mind, we have sought to assess the role of demand management based on a case study evidence review, together with a wider consideration of the mechanisms through which demand management operates, and how the impacts of these could vary 'in practice' across the 54 cities.

Types of demand management

6.5 There are many types and variants of demand management. However, in an urban context these essentially fall into three broad categories. These are:

- **Urban Congestion Charging**: This involves vehicles having to pay a charge either to enter a specified area (cordon charge) or to travel within a specified area (area-based or zonal charge). The London Congestion Zone, introduced in 2003, is the only large-scale UK example.
- **Workplace Parking Levy**: A Workplace Parking Levy (WPL) imposes an annual charge on businesses based on the number of eligible workplace parking spaces at their premises. The only UK example is the Nottingham WPL scheme, which started in 2008, although several are at a mature stage of development by local authorities.
- **Physical Demand Management**: These involve the physical restriction of certain vehicles from crossing specified entry points. Examples include city centre 'bus gates', adopted in a number of UK cities. Oxford has recently approved trial 'traffic filters' which would restrict car users (without a permit) from passing through filters which is aimed at reducing traffic levels across much of the central and inner areas of the city.

6.6 The first two of these approaches represent '**charging-based'** approaches in that they seek to deter car trips by increasing the '**financial' cost of travel**. The latter represents a '**physical-based'** approach in that, by removing routes for private cars or reducing capacity, they typically deter car trips by lengthening journey times and increase the '**time' cost of travel**. We do not consider 'distance-based' charging approaches, which would likely require in-vehicle GPS technology, as such systems would likely be national in scope and are unlikely be delivered at the scale of individual cities (or city centres).

Social and distributional impacts

6.7 An important consideration for the development and implementation of such approaches is their **distributional** impacts, and in particular the extent to which impacts vary across different social groups. Public acceptability challenges relating to the perceived fairness of introducing demand management – and in particular charging those who are perceived to have no alternative choice to car travel for their journey – have historically been a key factor for why such approaches have not been taken forward.

6.8 Our assessment highlights the potential distributional impacts of different demand management approaches, drawing from a review of the groups each approach targets. However, it should be highlighted that the distributional impacts of any approach will be highly locally specific, and pertain to the availability of alternatives to the car for the user and trip in question, the local context, and the design of any 'discounts' or 'exceptions' for specific users (e.g. blue badge holders, residents within a charging zone, etc.)

Congestion charging

Summary of evidence

6.9 Within both a UK context and abroad, there is proven evidence that both cordon and area-based charging can relieve traffic congestion, support mode shift, and generate additional revenue to help fund improved transport infrastructure (both for capital investment and ongoing subsidy). It should be noted that these schemes were typically, but not always, delivered alongside improvements in public transport. This evidence includes:

- The London Congestion Charge, which reduced private car trips entering the zone by 36% by 2007 relative to 2002, the year pre-implementation (21% of all 4+ wheeled vehicles);
- Electronic Road Pricing in Singapore, which has reduced weekday traffic entering the restricted zone by 24%;
- The (initial) Stockholm Cordon Charge, delivered in 2006, which resulted in a 22% reduction in traffic entering/exiting the congestion charging zone.
- The Milan 'Area C' congestion charge, which reduced traffic in the charging zone by 15%.

6.10 Notably, each of these projects was delivered in large city centres, each within a wider metropolitan area of more than 2 million people, and with mature, comprehensive public transport networks. We are not aware of any comparable cordon or area-based schemes that have been delivered in small or medium-sized cities.[21]

6.11 Figures vary for the level of charge in different cities – higher in London (£5 in 2003, £15 in 2023), lower in Stockholm and Milan (circa £3.50 and £2.20 to £4.40 respectively in 2022), but still material relative to the wider cost of private car and public transport alternatives. The different scale of impact in terms of traffic volumes reflects both the level of charge, the scale of 'exceptions' or 'discounts' (e.g. to local residents) and the local context.

Implications for mode shift and demand suppression

6.12 The evidence suggests that, across the cities examined, the introduction of charging has also seen an increase in public transport patronage. Within London, for example, bus passengers crossing the city centre cordon increased by 37% after the first year of operation. However, the introduction of the charge occurred alongside wider improvements to public transport – indeed the number of bus and coaches crossing the city centre cordon increased by 23%.

6.13 From the data available it is not possible to directly determine the extent that those travelling by car change to travelling by another mode. Broadly speaking, after the introduction of

[21] Durham has a congestion charging 'zone', but this is not comparable as it is a lower, £2 charge to access a very small geographic area (the 'peninsula' in Durham City – only one circa 650 m long street is subject to the charge).

charging for those who were previously driving to a city centre there are several potential outcomes:

- They continue to drive, to the same destination, and pay the charge;
- They change modes, to public transport or active modes **('mode shift'**) – note where congestion charging occurs in a small geography, this may include park elsewhere outside the zone and walking the 'last mile' to their destination;
- They no longer drive to a city centre but instead change their destination and travel elsewhere, for example shopping elsewhere, or (especially in the longer-term) working in a job outside the charging zone and employment consequently occurring elsewhere ('**destination switching'**);
- They do not travel at all **('demand suppression'**)
- They drive via a different route, avoiding the charge, if they were simply driving through the zone rather than to a city centre destination ('**route switching'**).
- They drive at a different non-charged time of day to do the same activity.

6.14 In the absence of empirical data or evidence, considering each of these outcomes is important to considering the likely economic implications for city centres specifically. This is summarised in the table below for the first five, which are most likely to occur in practice. Note this only considers the 'first-order' effects – revenue from charging can be used to fund wider transport enhancements, which have the potential to mitigate negative economic impacts.

Continue to drive	While charge payers experience a welfare disbenefit (a 'user charge'), there is no direct impact on city centre economic activity. Charging raises revenue but reduces long-term competitive advantage of city.
Mode shift	No direct impact on city centre economic activity, as individuals still travels to a city centre for work or leisure. People who change mode experience a welfare disbenefit. Potential benefit from reduced externalities of car travel, e.g. for urban realm, which may increase the attractiveness of city centre and hence deliver long-term economic benefits.
Destination switch	Lower city centre economic activity, as individuals now travel for work or leisure elsewhere. Implication that employment is adversely affected. People who change destination experience a welfare disbenefit.
Demand suppression	Lower city centre economic activity, as individuals now travel for work or leisure less frequently. Implication that employment is adversely impacted. Likely small in scale compared to destination switching. People who experience trip suppression have a welfare disbenefit.
Route switching	No net change in traffic but different routes taken change journey times and level of congestion in different areas with potential disbenefits. Significant for large cordons or charging zones (e.g. London); less relevant for small areas.

6.15 The likelihood of each of these outcomes will be different in different contexts, and there is very limited evidence regarding the relative share of each. However, it would be expected that the level of mode shift will be greatest in cities with the densest public transport networks, which provide a genuine, viable alternative to the private car on the basis of time, financial cost, quality and convenience. Typically, but not always, this is most likely to be the case in larger cities. For example:

- within London, with an unrivalled public transport network compared to other UK cities, even prior to the congestion charge the number of private car trips to/from the city centre for which private car was the fastest and/or cheapest mode relative to public transport (or park-and-ride) was very limited, if any. There was therefore scope for users to switch to other modes without any negative impact on their journey time or cost. Far more users will 'mode shift' as instead of 'destination switch' or not travel at all.
- within a 'large' city, such as Manchester or Birmingham, the public transport network offers a broadly good level of coverage and frequency, although for some journeys it will be less competitive (slower; more expensive; and/or less convenient) than private car. A greater proportion of car users 'priced off' by charging are likely to not find the alternatives suit their requirements, and hence either 'destination switch', or do not make the journey at all.
- Within 'small' cities, such as Burnley or Plymouth, the public transport network is typically less competitive than car for a significant number of trips. More users are likely to 'destination switch' as opposed to 'mode shift', with negative implications for city centre economies.

6.16 The London Congestion Charge model, an initial £5 charge (in 2003; now £15 with intermediate increases) applied to traffic within the charging zone is estimated to have reduced general traffic volumes by circa 21%, rising to 36% for cars, by 2007. The other international comparators (Singapore, Milan, Stockholm) of comparator schemes have delivered comparable changes in traffic volumes, typically around 20%, at a lower daily charge level.

6.17 The proposed all-day charge of £5 within Cambridge is projected to reduce traffic by 40 - 50%, but **only** if implemented alongside complementary investment in the public transport and active travel network, which is projected to increase bus trips by 30-50%, cycle trips by 15-30% and walking trips by almost 30%. Without this, the level of impact on traffic would be materially lower. However, this level of reduction in traffic and mode shift is forecasted, as opposed to observed and delivered in practice.

6.18 Assuming a £5 charge, based on the evidence available, we would expect a reduction in general traffic within the city centre cordons of 15 – 30% in the AM peak[22] dependent on the local context and the extent to which charging is paired with complementary investment, and:

- **The level of mode shift, versus destination switching, to be materially higher in larger city centres such as Birmingham, Leeds and Manchester** where the public transport networks are most comprehensive. Of the 15 – 30% reduction in highway trips, we would expect the majority of these to shift to other modes, with the majority of the remainder either 'destination switching' or 'route switching';
- This would **also be the case in smaller cities with strong city centre economies, and where significant complementary public transport investment is proposed**, such as Cambridge, which results in public transport and walking and cycling being strongly competitive for the majority of journeys;

[22] The scale of reduction is likely to be greater in the off-peak, since off-peak trips are typically for more 'discretionary' trip purposes e.g. shopping, and where there is more choice regarding the ability to make the trip and to which destination.

- However, **in most (but not all) small- and medium-sized cities and/or those with poor public transport connectivity, we would expect the level of mode shift to be significantly less**, a higher proportion of former highway trips to 'destination switch' rather than 'route switch'. This is more likely to have a potentially negative impacts on economic activity in such city centres, deterring employment growth due to the poor perceived alternatives to driving. Less ability to mode shift means individuals feel either 'forced' to pay the charge or instead travel elsewhere, and such schemes are likely to face even greater public and stakeholder acceptability challenge.

Wider benefits and costs of congestion charging

6.19 Policy decisions to adopt congestion charging in any specific city, alongside any other demand management approach, would be based on a wider set of benefits and costs, beyond the direct impact on traffic reduction and/or mode shift. Reducing traffic volumes within cities is associated with a wider range of benefits, including:

- **Faster (and more reliable) journey times arising from reduced traffic congestion**. Even small reductions in traffic volumes will typically result in reductions in congestion and faster journey times. For example, a year post-implementation of the London Congestion Charge, congestion reduced by 30%, despite a smaller reduction in all traffic of 14%. This led to 14% faster car journey times, a 6% improvement in average bus speeds and a 30% reduction in bus excess waiting time.[23] These changes would have resulted in:
    i. Productivity benefits for business and freight users, such as an ability to make more deliveries within the working day for a courier. Particularly for those with very high values-of-time, and those using vehicles within the charging area for much of the day, these benefits can exceed the financial cost of the charge, and in such cases they experience an overall benefit despite having to pay;
    ii. Welfare benefits for commuting and leisure users, for both private car and bus users. They will experience faster journeys, for the former in exchange for an increased financial cost.
    iii. Reduced operating costs for bus services, which directly scale with average bus speeds, and potentially a reduced requirement for ongoing subsidy.
- **Social and environmental benefits from reduced traffic volumes**, including:
    i. Improvements in local air quality (NOx; PM10s) and reduced carbon emissions (both from reduced traffic volumes **and** more free-flowing traffic conditions);
    ii. Reduced negative impacts of traffic on local ambiance and amenity and the 'place' function of cities;
    iii. Potential safety benefits.
- **Greater opportunities for road space re-allocation**, as reduced traffic volumes provide increased scope to remove space from general traffic to walking, cycling and public

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[23] Transport for London (2004) '**Congestion Charging Impacts Monitoring: Second Annual Report**'

Note that in London's case these benefits have been subsequently eroded over time, in part as road space has been re-allocated to other purposes since the introduction of the scheme in 2003, despite the reduction in traffic volumes being sustained over the longer-term.

transport which may not have been practically or politically feasible to otherwise implement. This includes:

i. Bus priority infrastructure (e.g. bus lanes);
ii. Better segregated cycling provision;
iii. Better pedestrian facilities (e.g. greater ‘green man’ signal times) or urban realm improvements (e.g. part-pedestrianisation of major junctions);
iv. Improved air quality and reduced severance/negative impacts of traffic on surroundings and better ‘place’ function for city centres.[24]

- **Greater revenue funding** enabling ability to fund wider transport improvements which would not otherwise be possible. Particularly in today’s constrained funding climate, there are numerous transport improvements which local/combined authorities would like to deliver but are unable to do so because of a lack of either capital or revenue funding. Greater revenue funding can help provide both:

  i. **Ongoing subsidy** for local bus, rail and/or tram services, to increase service frequencies, improve network coverage and/or directly subsidise fares;
  ii. **Capital funding** for new bus, rail and/or tram infrastructure, through providing an income stream that can be borrowed against.

  Directly linking demand management to transport improvements can also help ensure that public transport network provides a viable alternative to the car for those who were otherwise driving to city centres, and hence:

  i. Reduce the potential for negative economic impacts for city centres from demand suppression and destination switching;
  ii. Help make demand management politically deliverable, and help demonstrate that the positive impact of public transport connectivity will outweigh the negative impact of charging general traffic.

6.20 All of the above will deliver second-order **economic benefits** to cities, making them a more attractive place for firms to locate, and supporting and facilitating city centre employment growth in the longer-term. However, they should be balanced against the costs of a congestion charging system, including:

- the **financial impact** of charging on highway users who continue to drive (in economic terms the charge is a ‘user charge’);
- **longer journey times** and/or **welfare disbenefits** for those users who continue to travel, but switch to an alternative mode less suited to their journey;
- potential for **negative economic impacts** should drivers travel by extended routes to avoid passing through a congestion charge zone. These negative impacts would be felt by those taking an extended route and by other traffic on those routes;
- potential for **negative economic impacts** whereby users who were previously driving instead travel elsewhere or not at all, with the implication that employment is adversely impacted.

6.21 While a business case process can help assess each of the above, the extent to whether congestion charging is an appropriate policy tool is subject to the relative weight decision-

[24] Note that there are ‘trade-offs’ between these benefits – re-allocating significant road space away from general traffic may undermine the other benefits of the scheme in terms of reduced congestion. This has occurred, at least in part, in London, where levels of congestion have largely returned to pre-2003 traffic levels despite traffic volumes remaining below that before the introduction of the charge.

makers place on each of the above benefits versus costs. However, the overall core driver of the benefits of congestion charging is from reducing traffic volumes, and hence congestion, in cities, but via **mode shift** rather than **destination switching** or **demand suppression**, and hence avoiding negative economic consequences.

6.22 As discussed in Para 6.15, we would expect mode shift to be greatest within large cities and/or those with the most mature public transport networks. It therefore follows that congestion charging is likely to be best suited to such contexts, and where the car commuting mode share is already comparatively low.

6.23 Where car is the majority mode, and/or within most small and some medium-sized cities, it is unlikely even with significantly greater funding leading to improved public transport frequency and service coverage that the public transport network would be capable of matching the cost and convenience of travelling by car. Within these contexts, with lower levels of mode shift, the negative effects of charging are likely to be greater compared to the positives, and congestion charging is therefore unlikely to be an appropriate (or publicly acceptable) policy approach.

Potential social and distributional impacts

6.24 As considered in this study, congestion charging is applied to those users who **drive to, from or through city centres only**. On average, these users will be on higher incomes, since:

- Car ownership, distance travelled and trip frequency by car is strongly associated with increased income. People in highest income quintile drive travel circa 50% further by car each year than those in the lowest quintile[25]; 78% of households in the highest quintile have access to at least one car, compared to 62% in the lowest[26];
- Specifically for trips to city centres, within small and medium-sized cities car is unlikely to be the lowest cost mode of transport once parking costs are included[27]. For those who pay for parking, this means that few are driving to city centres on the basis of cost alone, and that users are driving because it is more expensive (in financial terms) in exchange for a faster or more convenient journey – which is more likely for those on higher incomes, who typically place a higher value on their time. Some drivers will have access to Private Non Residential (PNR) parking at no cost, but again on average it is expected that such people will be on higher incomes.

6.25 In practice, this will mean that the direct negative financial impacts of congestion charging on road users is more likely to be felt by those on higher incomes, especially in cities with already-high parking charges. Even so, there will be a proportion who incur the charge who will be on lower-than-average incomes and for these people the charge will have a greater negative

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[25] DfT Statistics (2021) Table NTS0705: Travel by household income quintile and main mode / stage mode: England, from 2002.

[26] DfT Statistics (2021) Table NTS0703: Household car availability by household income quintile: England, from 2002

[27] The cost of city centre car parking, even before other car costs are included, will typically be greater than travel by bus to a city centre destination. For longer journeys, parking outside the city centre and using park-and-ride is also typically cheaper. Typically, but not exclusively, parking charges are highest in the largest cities where land values are greatest, and in these city centres driving will be most associated with those in higher income brackets.

impact than those in the higher income groups. Within the largest cities, city centre focussed congestion charges will be felt by a relatively small number of people, in relation to the total urban population; only a very small proportion of residents regularly drive (for any purpose) to large city centres.

6.26 Consideration also needs to be given to people travelling by car for non-work purposes, for instance to go shopping or access leisure activities found in city centres. Some of these impacts can be mitigated through how the charging scheme is specified, but generally such people be expected to be from across the income spectrum and would incur a disbenefit.

6.27 Many of the benefits of congestion charging are likely to disproportionately benefit those on lower incomes, who are more likely to use public transport, and especially bus services. Outside London, people in lowest income quintile, for example, make 76% more local bus trips than those in the highest[28]. Those on lower incomes are hence more likely to:

- Benefit from faster journey times and improved reliability of bus services from the reduction in traffic congestion created by congestion charging;
- Benefit from of greater revenue funding being invested in the public transport network, especially if funding is directed into the bus network (or light rail)[29].

Implications for capacity requirements, investment approaches and capital costs

6.28 Introducing congestion charging, and delivering a circa 20% reduction in highway traffic, would in practical terms increase the scale of capacity requirement for public transport and active modes. Drawing from the earlier demand and capacity analysis, we have assessed:

- The scale of this increased requirement;
- The extent to which it cannot be accommodated by the existing transport network, and hence results in an increased capacity requirement for each city.

6.29 We have assessed this impact based on three assumptions for the level of traffic reduction and mode shift. As discussed above, we would expect the 'high' assumptions to be more likely to occur within the largest cities with the most comprehensive public transport networks. These assumptions are:

- '**low'** – 15% reduction in traffic, 50% mode shift assumption, remainder do not travel, travel elsewhere or via a different route;
- '**medium'** – 20% reduction in traffic, 60% mode shift assumption;
- '**high'** – 25% reduction in traffic, 70% mode shift assumption.

6.30 Considering the 'City Centre Renaissance' scenario, prior to introducing the demand management assumptions eight cities had a requirement for additional urban transport capacity by 2055. Applying the above assumptions:

- The scale of capacity requirement (for public transport and active modes) increases in each of the eight previously constrained cities, as a proportion of highway demand shifts

[28] DfT Statistics (2021) Table NTS0705: Travel by household income quintile and main mode / stage mode: England, from 2002

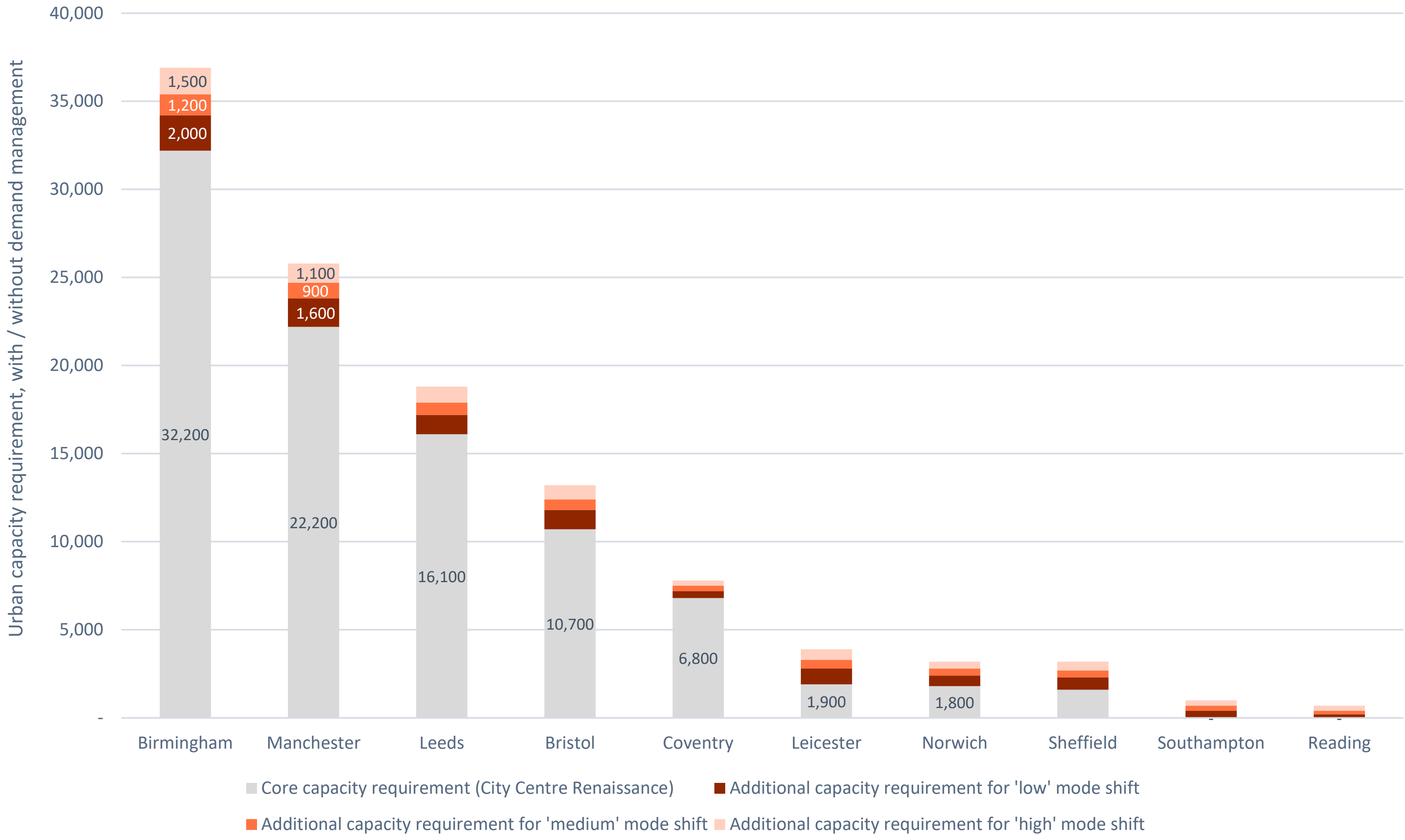
[29] Investment in longer-distance connectivity, especially rail, is more likely to benefit those on higher incomes, as these groups are significantly more likely to travel and commute longer distances to city centres that those on lower incomes.

to public transport. Under the 'high' assumptions, the increase in capacity requirement (for non-car modes) is circa 15%;

- For two cities, there is now an urban capacity requirement – with the additional mode shift from demand management, the transport network can no longer accommodate the increased demand to non-car modes arising from mode shift resulting from demand management;
- For the other ten cities, the level of mode shift away from private car can be accommodated within the existing transport network, and there continues to be no additional requirement for increased urban capacity.

6.31 Figure 6.1 summarises the scale of this potential increase capacity requirement for each city, again for the City Centre Renaissance scenario. The **grey** element of the bar represents the core urban capacity requirement, directly corresponding to the capacity requirements set out in **blue** bars in Figure 4.4. The **dark red** represents additional requirement from mode shift under the 'low' charging assumptions; and each additional element of the bar moving from 'low' to 'medium', and 'medium' to 'high', levels of mode shift as a result of introducing charging.

Figure 6.1: Potential effect of introducing cordon-based congestion charging on urban capacity requirements



6.32 We have not included these additional requirements within the capital costings for new infrastructure in Chapter 7, as the scale of increased capacity requirement across different modes is highly uncertain and would be context-specific.

6.33 The reduction in highway demand would be expected to result in a greater ability to increase public transport and active travel capacity and potentially at lower cost – for example, less traffic making it easier to introduce bus priority measures and segregated active mode facilities, as well as reducing bus operating costs by reducing the negative impact of congestion. Revenue from charging would also help fund enhanced infrastructure and services which would otherwise not be available to cities.

Workplace Parking Levy (and other parking controls)

Background and summary of evidence

6.34 Parking charges can have an important role in deterring car usage, and the cost (and availability) of parking plays an important role in the decision of a user to drive to their destination, or where to travel for discretionary trips. Parking can be provided either in private car parks (charging the 'market rate' based on the scarcity, value of the land and the customers' willingness to pay, or discounted or free in the case of leisure or shopping destinations), public car parks or on-street (charges set by the local authority), or by private workplaces (often for free or heavily discounted).

6.35 Within this context, except for where a very large proportion of parking is provided by the local authority, there is limited scope for the public sector to directly use parking as a policy lever to manage demand. The exception is through a Workplace Parking Levy, of which Nottingham forms the sole delivered UK example.

6.36 The Nottingham scheme applies a charge per private workplace parking space, In 2022/23 this is £458, equating to circa £2 a day for a worker driving to work 5 days a week. However, this is **only** charged for commuting trips for where the parking space is provided by the employer (and for Nottingham if the employer has more than 10 spaces). This is only a narrow sub-set of car commuting journeys – in Nottingham we estimate circa 37% of car commuters – and an even smaller subset of all highway trips to city centres are affected by the WPL. Also, a significant proportion of employers do not pass on the charge to their employees (equivalent to around half the licensed spaces).

6.37 Compared to a cordon charge, where a £5+ daily charge is applied to the vast majority of city centre private car trips, the number of 'in scope' movements for charging is far smaller, and the daily charge they are in effect paying (circa £2 in the case of Nottingham) also smaller. It is therefore expected that the impacts on highway demand and mode shift are also significantly smaller than for a 'congestion charge' type approach.

6.38 Within Nottingham, ex-post evaluation evidence suggests:

- Of those commuting by non-car modes, 4.4% responded that they switched from the car in part due to either an increase in the cost of parking at work, or the removal of parking at work. This increases to 8.6% if they reported switching from the car due to PT and cycling improvements funded by the WPL itself (which would not otherwise have been delivered);
- Since non-car modes account for circa 47% of all commuting trips (2011 Census data), this 4.4% and 8.6% equates to a circa 3.5% increase in the use of non-car modes for journeys

to work linked to the WPL itself, or 7% if the complementary transport investment it helped fund are also included;

- Accounting for other general traffic for non-commuting trip purposes would reduce the aggregate level of mode shift further, likely to circa 1-2% and 3-5% respectively for WPL alone and WPL plus funded measures;
- The ex-post evaluation suggested that, additionally, a quarter of car commuters surveyed had switched to the car since 2010 – in part due to the release of highway capacity caused by the above effects. This reduces the net level of mode shift, with the study concluding there is "*evidence of significant suppressed demand for travel by car and this may be obscuring the beneficial impact on individual mode shift of the WPL package*".

Implications for mode shift and demand suppression

6.39 The implication of the above is that the WPL can play a role in supporting modest levels of mode shift from private car to more sustainable levels of travel. It also highlights that the 'carrot' of improved PT capacity (funded by the WPL) was of comparable importance as the 'stick' of the charge itself in driving travel behaviour.

6.40 However, the size of the levy, and its applicability to only a small proportion of all AM peak hour traffic, is likely to mean that the level of reduction of highway demand and mode shift to public transport and active travel is likely to be relatively modest in absolute terms – perhaps 1-2% - when compared to the total demand crossing the city centre cordons.

6.41 Hence, WPL can play a role in supporting mode shift and raising revenue to help fund local transport enhancements (in the case of Nottingham, a major expansion of their tram network). These enhancements will, in turn, increase the overall capacity of the transport network – and for a city or local authority with large funding pressures not be affordable without it. However, the direct impact of WPL **itself** on user behaviour on demand crossing city centre cordons by mode – the focus of our study – is likely to be small in practice and we have not assessed it further.

6.42 Were higher WPL charging levels to be introduced, we would expect the impact on highway demand and mode shift to be materially greater. However, it should be noted that:

- for city centres where a high proportion of parking is provided at private car parks not at workplaces (e.g. contract parking in commercial car parks), there are no current powers available to local authorities for this to be subject to charging, and this will limit the ability of a higher level of WPL to be implemented in practice (as individuals simply use a cheaper, private car park instead);
- for small city centres, where there is significant free on-street parking outside the cordon but within walking distance of the city centre, this would also constrain the effectiveness of WPL, particularly with higher charging levels – as individuals can simply park on-street and walk to the workplace.

6.43 Reducing or limiting parking provision within city centres would be expected, in isolation, to increase the cost of parking and hence deter car journeys, especially for commuting trips where spaces are typically occupied 'all-day'. The nature and type of impact would be expected to be similar to for congestion charging by reducing city centre traffic, but the scale will be dependent on the extent to which parking is reduced, and the price increased.

6.44 Since the ability of local authorities to manage or reduce **existing** commercial parking is limited, it is unlikely that this can make a material contribution to reducing city centre traffic volumes, outside of a small number of cities where the local authority is the major provider of public parking.

Wider benefits and costs of a workplace parking levy

6.45 The discussion and evidence above highlight the **net** impact on mode shift and traffic volumes of a WPL similar to Nottingham is likely to be very modest in practice. Hence, the effects of a WPL on journey times and decongestion; local air quality; carbon emissions; local environment; and opportunities for road space reallocation are also likely to be small, even if some individuals do adapt their behaviour in response to the WPL. The nature of the benefits will be comparable to congestion charging (as set out in Para 6.19), but far smaller in magnitude.

6.46 The core benefit of the WPL is instead the ability to raise significant revenue to fund transport enhancements. This is demonstrated in Nottingham, where the revenue raised by the scheme helped fund a major £570m, 18 km expansion of the tram network, redevelopment of Nottingham station and ongoing financial support to the bus network. Each of these delivers a wider set of social and economic benefits, which can at least in part be attributed to the WPL.

Potential social and distributional impacts

6.47 A WPL is applied as a charge for those who drive to workplace-provided parking. Since commuting by car is also associated with higher incomes, overall the net effect is greatest on those on higher incomes. However, unlike city centre congestion charging, it should be highlighted that:

- a WPL is typically applied across an entire local authority geography. Within this, there will be many workplaces and car commute journeys which are poorly suited to any other mode, and where public transport will be significantly longer and/or more expensive. Some of these journeys will be made by those on lower incomes, who will perceive they have no alternative to drive;
- compared to commuting to a city centre, one would expect less variation in car commute mode share by income. Compared to congestion charging, proportionally more revenue would be expected to be raised from those on lower incomes. The personal impact of the charge (at circa £450 per year) will be greater for an individual on a lower than higher income, as it accounts for a greater share of their total income;
- since a WPL is applied across a wider geography, the total number of people affected is likely to be substantially greater than a city centre congestion charge;
- in contrast to a congestion charge, only commuters are affected. People travelling by car for other purposes would incur no extra charge.

6.48 Similar to congestion charging, the overall distributional impact will also depend on how revenue raised from the charge is spent. In the case of Nottingham, the greatest benefits from improvements to bus services and expansion of the tram network are likely to have been felt by those on lower incomes and/or more disadvantaged groups. Specific discounts from the WPL can help alleviate negative distributional impacts – for example excepting blue badge holders or NHS staff – and since the charge is levied on the business itself, it is the businesses decision whether to pass some or all of the charge onto its employees.

Physical demand management

Summary of evidence

6.49 There is a broad range of evidence of different types of physical demand management, all with the common aim of restricting access to general traffic and hence deterring use at different scales. These range from:

- local measures such as 'bus gates' on specific streets;
- traffic filters introduced to limit or constrain access specifically to city centres (such as within Cambridge and Groningen); and
- wider, 'area-based' measures which restrict traffic movements between distinct zones across a wider city geography, such as proposed in Oxford and often referred to in a UK context as 'Low Traffic Neighbourhoods'.

6.50 The wide scale over which these measures are implemented can make it challenging to assess and compare their impacts, particularly at a 'network level' as opposed to specific streets as traffic re-routes on the network.

6.51 Within Ghent, after the delivery of the New Circulation Plan, focused on movements across and within the city centre, overall peak hour car traffic is reported to have fallen by 12%, increasing to 29% on specific routes within the ring road and 58% on local, residential streets, with a 25% increase in cycle traffic and 6% in public transport, indicating the potential for a high level of mode shift. Similar findings have been reported from early research for Low Traffic Neighbourhoods within London.

Benefits and implications for mode shift and demand suppression

6.52 The primary means by which such schemes are successful in reducing traffic is by making traffic to take longer routes – for example, rather than driving through a city centre or residential area, a driver would be required to make a longer journey via a boundary or ring road to make their journey. This lengthens journey times, increasing the 'time' cost of travelling, and encourages travel via an alternative mode (or destination, route or not at all).

6.53 This also delivers a significant benefit to the street or corridor which has been filtered (indeed, this is the primary objective), which will experience a large-scale (50%+, dependent on if some vehicles are exempt) reduction in traffic, which dependent on local context can:

- release significant capacity for public transport in the managed area by removing general traffic (e.g. 'bus gates' delivered in Cambridge city centre, Manchester and elsewhere – all of which by removing general traffic have released capacity for local bus services and typically led to faster journey times and reduced bus operating costs, and will support local mode shift);
- enable urban realm improvements, and road space reallocation to walking and cycling;
- improve the local ambiance by virtue of removing traffic, reducing noise, severance and improving air quality; and
- result in second-order health benefits from increased active travel.

6.54 Unlike charging-based approaches, physical demand management does not directly raise revenue, and schemes are primary justified on the basis of the social and environmental benefits above. These benefits must be balanced against longer journey times for those who continue to drive and must take a longer route, and potentially greater traffic volumes and/or congestion on 'boundary' roads to which traffic is displaced.[30]

6.55 It should be highlighted that such schemes will generally be most effective at deterring short-distance car journeys. This reflects how the level of 'inconvenience' will generally be lower for longer-distance car trips – both in terms of total time (likely only one 'end' of the trip affected by traffic filters) and proportional impact (a longer journey by 5 mins will be perceived as more inconvenient on a 10 min drive compared to a 60 min one). This partly explains how:

- Mode shift is especially greater towards active modes, which are used over shorter distances, compared to bus and (especially) rail;
- For the proposed traffic filtering scheme in Oxford, car trips *wholly within* the city are expected to reduce by 20%, but the reduction for all trips *to and from* the city is less, at 9%.

Potential social and distributional impacts

6.56 The nature of the social and distributional impacts of physical demand management will depend strongly on the nature of the scheme and the geography over which it is implemented.

6.57 The distributional impacts of physical demand management in **city centres** would be expected to broadly similar to that of congestion charging. Disbenefits for those who drive to and within city centres (from longer journey times from a more inconvenient route) are largely focused on higher income groups, and benefits from improved public transport to those on lower incomes. Benefits from improved urban realm and traffic reduction are likely to accrue to those living and working in the immediate surroundings of the access restrictions. Any disbenefits to areas where traffic may re-route to will depend on the characteristics of the areas concerned.

6.58 Specific exceptions can be applied for blue badge holders, and/or local residents, where ANPR infrastructure is used. The proposed Oxford traffic filtering scheme is innovative in proposing to allow Oxford residents a 100-day pass per year to drive through the filters (and Oxford**shire** residents a 25-day pass)[31] which focuses the negative impacts on those who drive very regularly within the city, but at the expense of reducing the overall benefits of the scheme on traffic reduction.

Implications for capacity requirements

6.59 The implication of this for urban capacity requirements is complex. Physical demand management can, in effect, provide a means of delivering increased net capacity but at the expense of that for general traffic. It is unlikely to broadly change the overall net capacity requirement for cities, but it should be noted:

- When considering urban capacity requirements, particularly over shorter distances within city centres and their immediate surroundings, physical demand management can help

[30] The level of traffic displacement, and any negative impacts on boundary roads, will be context-specific and dependent on the level of mode shift and demand suppression versus displacement to other routes.

[31] BBC News, **'Oxford's £6.5m traffic filter trial set to be approved'**, 22 November 2022

enable and support mode shift to walking, cycling and public transport. At a local level, it will make a city centre more attractive to access by walking, cycling or public transport, and less so by car. This evidence suggests this typically, but not always, leads to local economic benefits to city centres and other neighbourhoods;

- Targeted physical demand management can support and enable road space reallocation along specific corridors, enabling significant increases in public transport capacity (and frequency, speed and reliability) that would not otherwise be possible, and supporting mode shift to these modes. Both the Eastside and Westside Extensions of the West Midlands Metro, for example, runs along previously major highway corridors into Birmingham City Centre along which general traffic is now prohibited;
- However, physical demand management is of **reduced importance** when considering **longer-distance demand to city centres**, and in many cases will only result in a small increase in the perceived cost for such trips.

6.60 The exact impact of physical demand management on the capacity of different modes will also be highly scheme and context-specific. For example, a scheme may significantly reduce highway capacity by removing access to general traffic for a core highway corridor entering a city centre, reducing net highway capacity. However, if this space is re-allocated to public transport or active travel infrastructure, there is the potential for the overall net transport capacity and demand along the corridor to increase. However, this will be dependent on the extent to which the new public transport and active mode capacity is ‘taken up’, itself based on exact pattern of former highway trips and their potential to shift mode.

7 Implications for infrastructure requirements and capital costs

Introduction

7.1 This Chapter explores the scale of infrastructure needed to deliver the required capacity for the nine capacity uplift scenarios from Chapter 5, and discusses:

- the broad scale, and quantum of bus, light rail and heavy rail infrastructure required to deliver a given uplift in capacity;
- the key uncertainties in the scale of this infrastructure requirement;
- the estimated capital costs of this additional infrastructure, and the level of uncertainty;
- the potential operating costs of this infrastructure versus fare revenue, and the key factors that underpin this assessment.

7.2 It should be highlighted that the cost estimates developed for each of the capacity uplift scenarios should be viewed as an order of magnitude estimate only. Our approach is not intended, and should not be used, to be representative of the infrastructure a specific city would, or should, deliver to achieve the specified capacity uplifts, nor the costs of any particular intervention.

Approach

7.3 Fundamental to our approach is the principle that capital costs (and infrastructure requirement) do not increase linearly with capacity requirement. We adopt a simplified framework for:

- assessing what **scale of infrastructure** is required to deliver a given uplift in capacity for each mode;
- **costing this infrastructure** on the basis of established unit rates, evidenced assumptions and professional judgement.

7.4 The approach is focused on developing an aggregate assessment of capital spend for the 54 cities as a whole. As such and to inform understanding of potential national infrastructure spending to 2055, it is **only** intended to be used to consider funding requirements across the range of cities as a whole. It is **not** intended to be used to determine the infrastructure requirements and associated capital costs for **specific cities**, which would require far more comprehensive local assessment. An overview of the cost assessment process is provided in Figure 7.1.

Figure 7.1: Summary of cost estimation process

Understanding infrastructure requirements

7.5 The output from our analysis is a simplified metric of a city's capacity requirement – the scale of capacity required for each mode crossing the city centre cordon in the AM high peak hour. This may, or may not, lead to a need for infrastructure spending, since:

- Many transport networks, even if operating at capacity, still have the ability for capacity to be readily increased without incurring major capital spending, for instance by running longer or more frequent trains and trams, and/or increasing bus frequencies;
- Where this cannot occur, the scale of infrastructure required will be context-specific – one city's rail network, for example, may simply require some platform lengthening and additional rolling stock, while another may need a major redevelopment of its principal station – this is an example of why our costs should only be considered at the aggregate level across cities;
- Infrastructure requirements and associated capital costs rarely increase linearly with capacity requirements. While it can be relatively straightforward to derive a small uplift in capacity through 'quick wins' – platform lengthening on the rail network, a frequency upgrade to enable more trams – there becomes a point this is not possible, and far greater spending must be incurred to increase capacity further and this capacity will be a step change, for instance through the construction of a new light rail line.

7.6 Our approach is based on several key principles, discussed below.

What scale of infrastructure is required to deliver a given uplift in capacity for each mode?

7.7 Firstly, a small scale of increased capacity can be provided readily – such as by increasing bus service frequencies, running more trams on existing infrastructure, or lengthening peak-hour trains. This initial uplift capacity can be provided at relatively low cost (in capital cost terms), often simply the cost of additional rolling stock and perhaps depot costs or modest station modifications, and the scale of these costs is relatively well-understood.

7.8 However, above a certain threshold, there reaches a point where capacity cannot be incrementally increased, and significant infrastructure spending must be incurred, for example:

- Bus frequencies can no longer be increased, and new dedicated priority (or BRT) infrastructure must be provided along corridors to enable bus capacity to be increased further – e.g. dedicated lanes, changes to junctions, new stop infrastructure;
- Tram services cannot be further lengthened or made more frequent, and new lines must be built both to increase capacity and the geographic coverage of services;
- Rail services cannot be further lengthened or made more frequent without significant infrastructure enhancements – such as signalling enhancements, increasing track capacity or capability, and/or station upgrades to enable more frequent and/or longer trains.

7.9 The thresholds for each step change in capacity are highly context-specific – different for different cities, corridors and modes – and the limited data available makes in challenging in practice to determine when new infrastructure will be required. We have adopted thresholds for each mode based on evidenced assumptions for when we assume new infrastructure must be delivered to gain a further increase in capacity. These assumptions are detailed in the Methodology Report. Costs are based on established unit rates from comparable projects.

7.10 We assume that when thresholds are reached, a cost is incurred to provide new infrastructure to support an increase in capacity. For example, this might be a new light rail line, enabling 12 additional trams per hour with the capacity for circa 4,000 extra people. Our modelling then assumes this increases the capacity of the network by 4,000 people. If the demand requirement exceeds this, then a second line must be built, and potentially a third or fourth, with the infrastructure cost scaling accordingly.

Limitations on surface capacity

7.11 At very high-capacity requirements, however, there becomes a point where the physical constraints of cities limit the ability for additional capacity to be provided at grade. Above this point, very high-cost (potentially tunnelled) solutions will be needed:

- **For bus**, city centre constraints (both street capacity and kerb space for bus stops) forms a practical limit for increasing services further. This means that, in practice, a low-cost, bus-based investment approach cannot accommodate high capacity requirements in the largest cities;
- **For metro and tram**, similar to bus, urban city centre streets cannot indefinitely support increased and/or longer trams or additional routes, and at some point complete segregation from traffic and pedestrians is required, at least in the city centre where services frequencies are greatest and street space is most constrained. In this case, the only practical solution may be tunnelling – an example is the construction of the *Het Souterrain* tram tunnel in The Hague, the Netherlands, which opened in 2004. This represents a step-change in capital costs, for which there are no comparable UK equivalents;
- For **rail**, fundamental constraints on existing infrastructure will limit the extent that capacity can be added incrementally, and there will be a point where major new urban rail terminal capacity or cross-city rail links, likely underground, are required. An UK example is the £18bn Elizabeth Line (Crossrail), the majority of the cost of which was 21 km (13 miles) of twin-bore tunnels, two underground grade-separated junctions and 10 underground stations. Although a comparable investment in Birmingham, Manchester or Leeds would not be of the same scale, it would be this type of project (i.e. tunnelled railway with underground stations) that would likely be required to deliver the uplifts in rail capacity for these cities projected within our high requirement rail-based investment approaches.

7.12 Since there are very few comparable projects, and only a very limited understanding of the physical constraints of cities, we have adopted an additional 'cost allowance' to capture the potential costs of such transformatory infrastructure, of £2bn for tram and £4 – 16bn for rail, for the very highest capacity requirements (more than 15,000 extra people per hour for tram and 12,000 for rail).

Understanding uncertainty

7.13 It should be recognised that defining the point at which new infrastructure (especially for rail) is required to accommodate a given capacity requirement has great uncertainty. Some cities, for example, may already lack the ability to increase capacity readily by lengthening or running more frequent trains without extensive infrastructure enhancements. Others may have opportunity to do so.

7.14 Conversely, some increases in capacity may be available by changes in rolling stock or operating patterns, which we have not explored in detail. For example:

- Most rail rolling stock operating into cities outside of London does not have high-density layouts, and prioritises seating space and comfort rather than overall capacity. Higher-density carriage layouts, such as on Class 700 'Thameslink' trains, can increase capacity by 30-40% for the same unit of train length compared to lower-density layouts which are typically used for commuter services outside London. A change of layout providing more capacity from standing space but reducing passenger comfort for some travelling in the peak could enable capacity to be readily increased at far lower capital cost than alternatives. The new rolling stock being introduced on the Merseyrail network and the Tyne & Wear Metro has greater capacity per car than the stock that is being replaced while still offering sufficient seats for all those travelling outside the peaks to be seated should they wish;
- Bus services in cities outside of London typically operate vehicles with one door for both boarding and alighting, and have more complex fare structures/ticketing which lengthen bus dwell times. If services operated double door vehicles and had a simple 'flat fare' system like in London, by reducing dwell times this could reduce stop dwell time and therefore increase stop capacity and enable more bus services within constrained city centres than would otherwise be possible (albeit with lower capacity per vehicle). However, outside a franchising model implementing this approach is not currently possible without the agreement of bus operators. Additionally, some cities have introduced longer, tri-axle double-decker buses which have the potential to increase capacity per bus compared to conventional vehicles[32].

7.15 Within the capital costings, we have broadly assumed that additional capacity is provided on a 'like-for-like' basis vis-à-vis current provision and we have not assessed the implications of the above in detail. However, they have been used to inform the sensitivity testing and the range of costs provided.

Implications for capital costs

7.16 Reflecting the discussion above, Figure 7.2 presents a stylised version of how capital costs for infrastructure scale with capacity, highlighting:

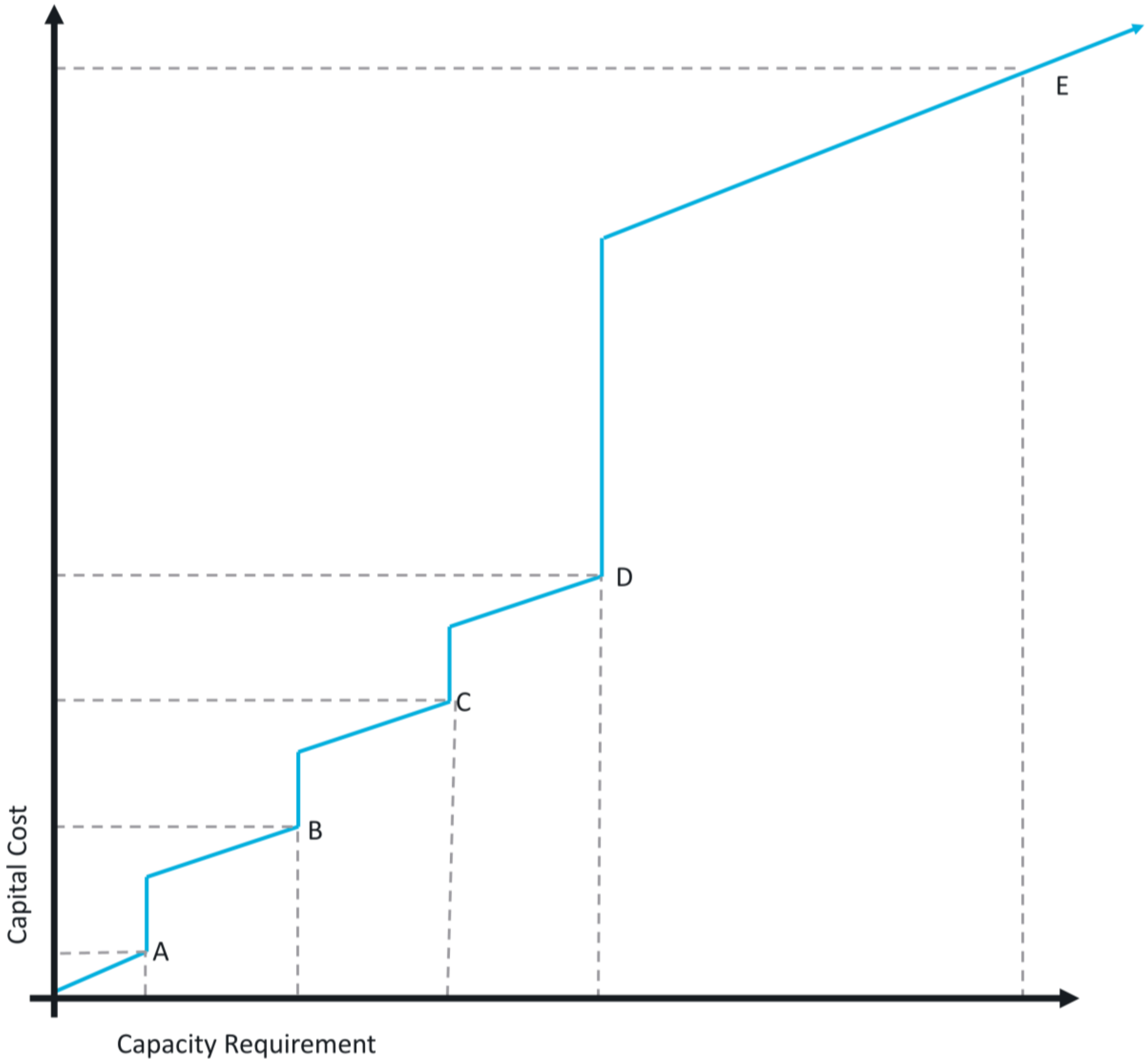
- When the requirement for additional capacity is relatively modest, capacity can be increased at relatively low capital costs (up to point A), perhaps requiring only new rolling stock, with a small scale of additional investment;
- Above a certain threshold (point A) there will be a requirement for major new infrastructure investment – perhaps a new cross-city tram line, new BRT corridor or major station upgrade – with a potential cost in the tens or hundreds of millions. Once built, this investment enables a further increase in capacity at relatively modest incremental cost –

[32] Bus operators in both Edinburgh and Cambridge have recently introduced higher capacity 13.9m Enviro400XLB buses, with a total capacity up to 129 people versus 87 for a conventional 10.9m double-decker – a circa 48% notional increase.

for example, running more frequent trams on the new line or additional rail services into the now-upgraded station;

- However, above a further threshold (at B and C) there is a need for further major infrastructure investment – such as another tram line or grade-separation of a major rail junction to enable extra services to run. Again, this incurs significant capital cost, but enables capacity to be increased further;
- Eventually, the opportunities to increase capacity further with 'conventional' infrastructure enhancements such as station upgrades or new tram lines become very limited. Above this point, the only realistic option is a large-scale, transformatory investment to deliver a step-change in overall capacity – up to point E and beyond. This point is very difficult to determine at an abstract level, and the nature of the investment very different for different cities, but as an example could represent:
    i. A new underground light rail line with stations, entirely segregated from on-street activity, which enables a step-change in tram frequencies and lengths across the wider network;
    ii. An underground heavy rail line, linking to existing surface rail infrastructure, which overcomes terminus constraints in the city centre – similar to London's Elizabeth Line (Crossrail).

Figure 7.2: Relationship between capacity requirements and capital costs



Estimates of capital costs

Capital costs for a given infrastructure requirement

7.17 The above approach underpins how capital costs scale with the increased capacity requirement. Figure 7.3 to Figure 7.5 summarise the broad scale of cost to deliver a given level of capacity for each mode, plus the broad scale of uncertainty.

7.18 Each illustrates the broad cost of increasing capacity, via a given mode, for a specific capacity requirement. They highlight the principle that capital costs (and infrastructure requirement) do not increase linearly with capacity requirement, as more complex and costly infrastructure requirements are required as the overall capacity requirement increases, as does the broad scale of uncertainty.

7.19 Table 7.1 summarises the infrastructure assumed to be provided for a given capacity requirement, and the broad scale of capital costs (in 2022 prices) this is associated with. These infrastructure requirements, and the range of costs, are used to derive the cost estimate for each capacity uplift scenario.

Figure 7.3: Estimated heavy rail infrastructure costs, by scale of capacity requirement

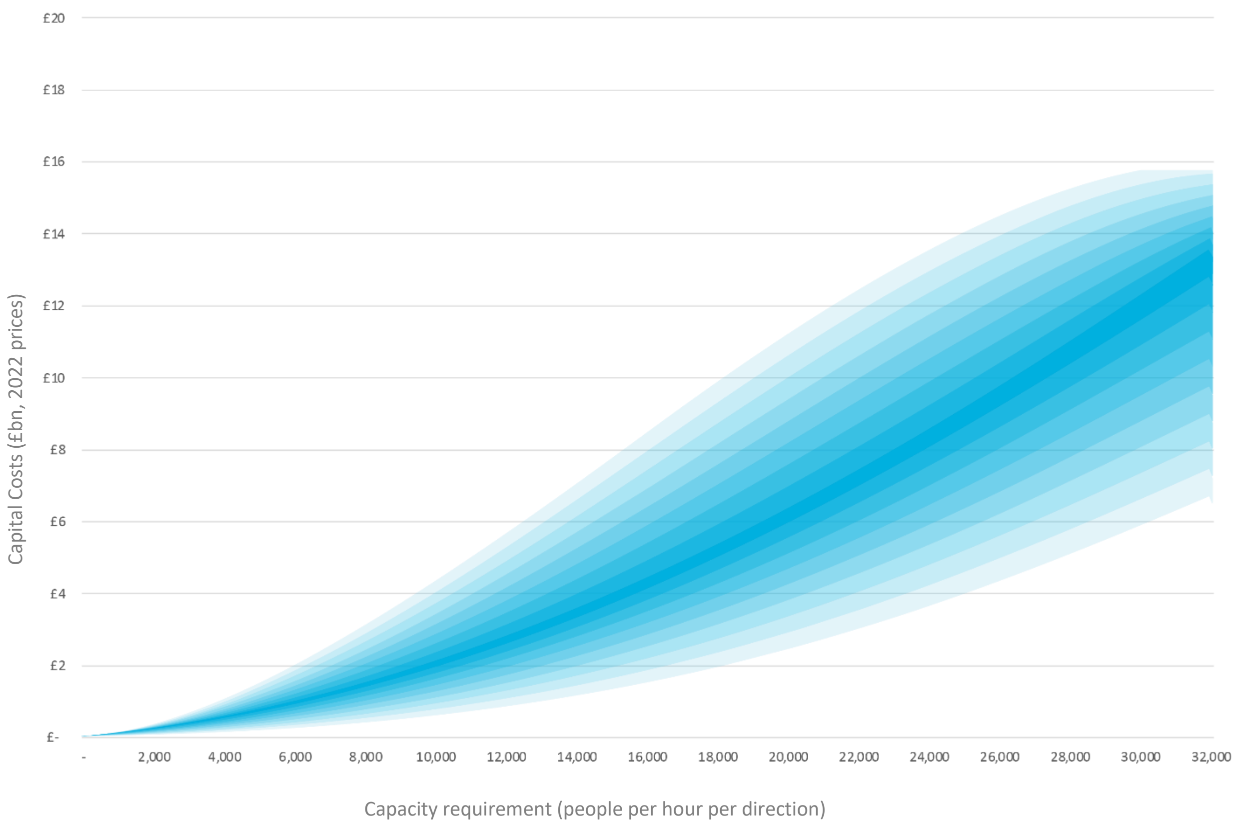


Figure 7.4: Estimated metro / light rail infrastructure costs, by scale of capacity requirement

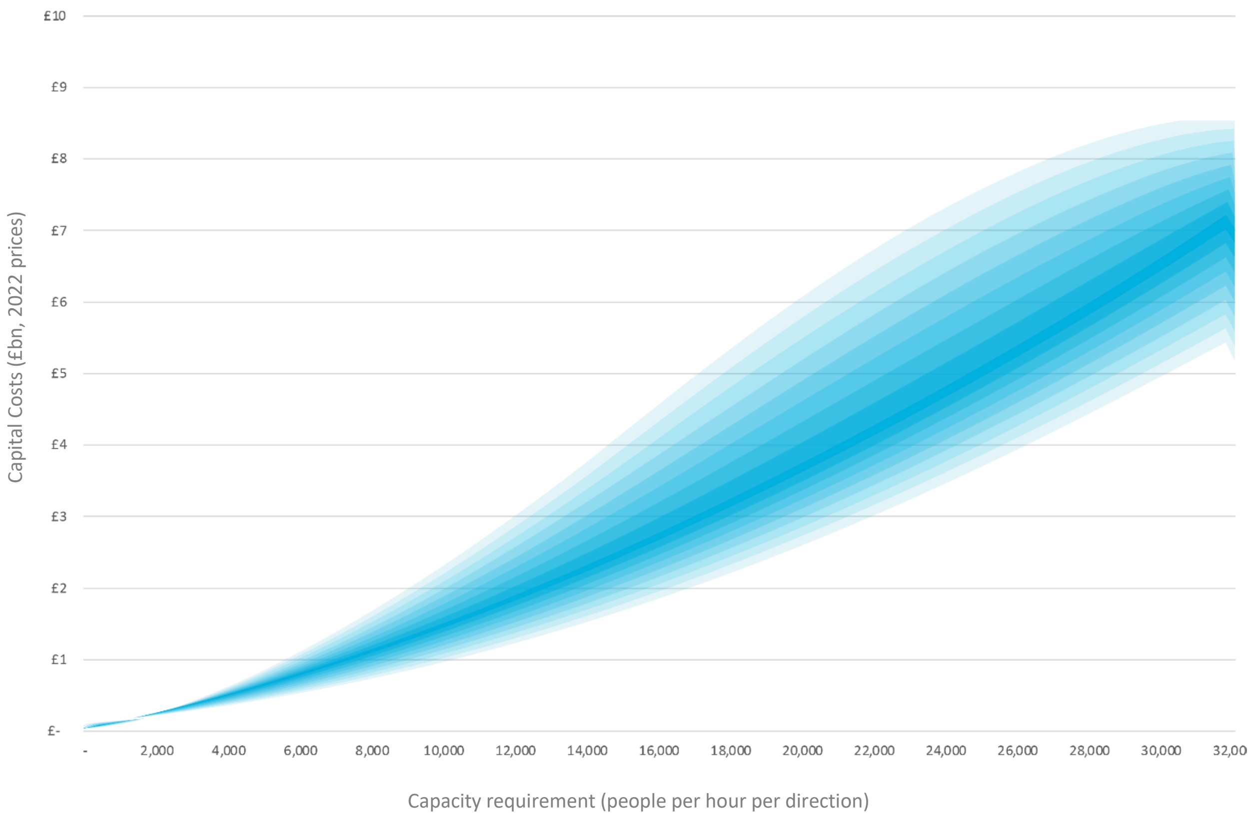


Figure 7.5: Estimated bus (and bus rapid transit) infrastructure costs, by scale of capacity requirement

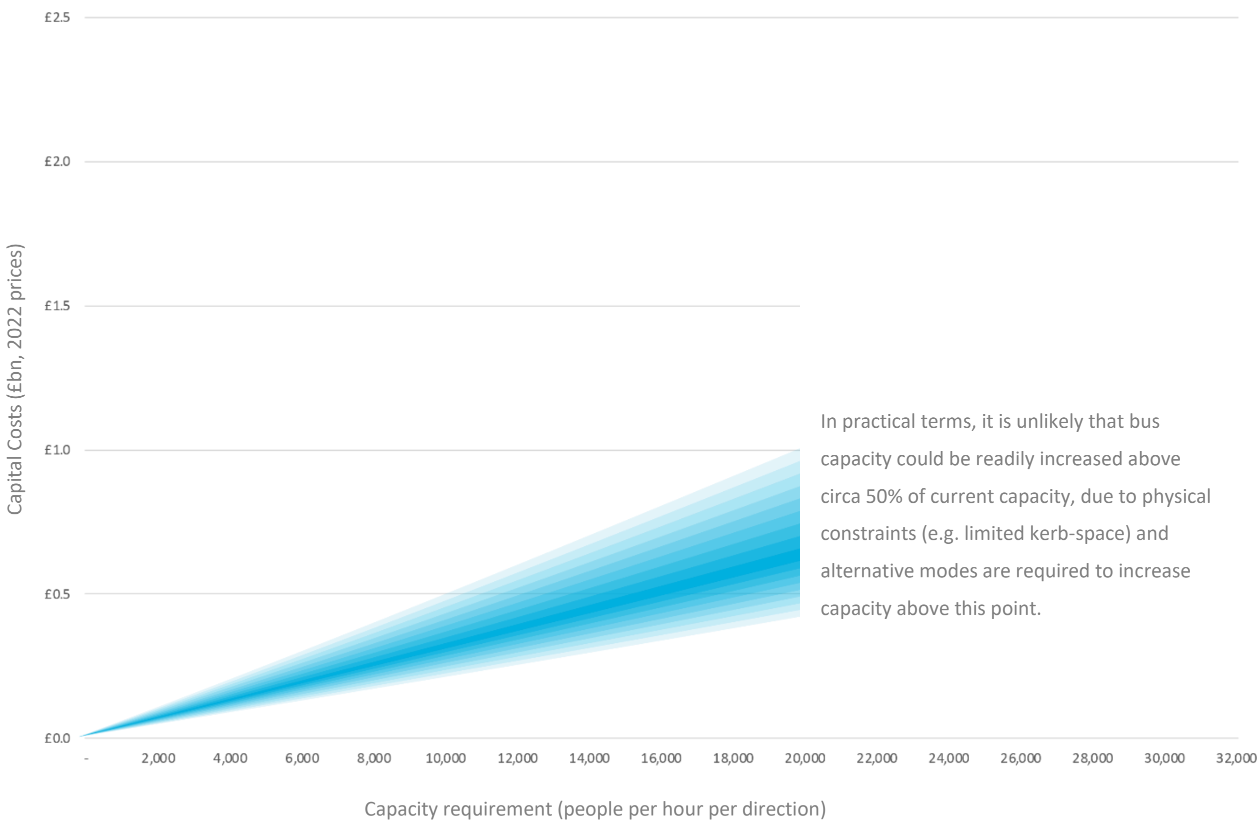


Table 7.1: Broad infrastructure and cost assumptions, 2022 prices

Capacity requirement (people per hour per direction)	**Rail >>**			**Light Rail >>**			**Bus >>**		
	Equivalent increase in capacity	Infrastructure requirement	Broad capital cost	Equivalent increase in capacity	Infrastructure requirement	Broad capital cost	Equivalent increase in capacity	Infrastructure requirement	Broad capital cost
500	4 additional rail carriages per hour	Limited – potential platform lengthening	£10 – 40 million	3 extra tram cars per hour	None	£10 million	6 extra double-decker buses per hour	None	£2 million
1,000	7 additional rail carriages or 1 – 2 extra trains per hour	Platform lengthening and/or signalling enhancements	£20 – 120 million	5 extra tram cars per hour	None	£15 million	11 extra double-decker buses per hour	None	£3 – 5 million
2,000	14 carriages or 2 – 3 extra trains per hour	Platform lengthening and/or signalling enhancements; minor station upgrade	£60 – 180 million	10 extra tram cars per hour	None	£30 million	23 extra double-decker buses	Up to 20 km of bus priority measures and corridor improvements	£7 – 60 million
5,000	36 carriages or 4 – 5 extra trains per hour	Platform lengthening, signalling and station upgrade(s)	£270 - £1,300 million	25 extra tram cars per hour	1 – 2 extra tram lines, circa 12 km	£680 – 860 million	**57** extra double-decker buses	Up to 40 km of bus priority measures and corridor improvements	£70 – 230 million
10,000	71 carriages or 8 – 10 extra trains per hour	Platform lengthening, signalling upgrades, and major city	£1,400 - £5,600	48 – 50 extra tram cars per hour	2 – 3 extra tram lines, circa 24km	£1,300 - £2,500	115 extra double-decker buses	30 – 90 km of priority measures and corridor improvements	£180 – 500 million

		centre station upgrade							
15,000	107 carriages or 12 – 15 extra trains per hour	Platform lengthening, signalling upgrades, major city centre station upgrade. Potential requirement for tunnelled infrastructure	£1,700 - £10,000	70 – 75 extra tram cars per hour	3 – 5 extra tram lines, circa 36km Likely requirement for new city centre tram infrastructure	£2,000 - £5,300	172 extra double-decker buses	50 – 140 km of priority measures and corridor improvements	£300 – 780 million
30,000	214 carriages or 20 – 30 extra trains per hour	Platform lengthening, signalling upgrades, major city centre station upgrade. Major new cross-city rail infrastructure (assumed tunnelled)	£6,400 - £14,900	140 – 150 extra tram cars per hour	5 – 8 extra tram lines, circa 72km New underground cross-city tram line	£6,000 - £8,700	Not realistic to provide scale of capacity via bus		

Capital costs per scenario

7.20 The following section presents the estimated capital costs of delivering additional infrastructure to meet the low, medium and high-capacity requirements with each investment approach. Infrastructure costs include both rolling stock (additional buses, trams and rail coaches) and fixed infrastructure such as new tram lines, bus priority infrastructure, platform lengthening, signalling enhancements and station upgrades.

7.21 Costs are provided in 2022 prices. The core cost estimate (the height of the bars) reflects a plausible view of the point at which new infrastructure is required for a given level of capacity requirement. The error bars represent the scale of uncertainty, and the cost estimate assuming a ‘pessimistic’ and ‘optimistic’ view of the point and scale of additional infrastructure required (e.g. a reduced or increased need for new underground infrastructure to accommodate very high capacity requirements on heavy rail and tram).

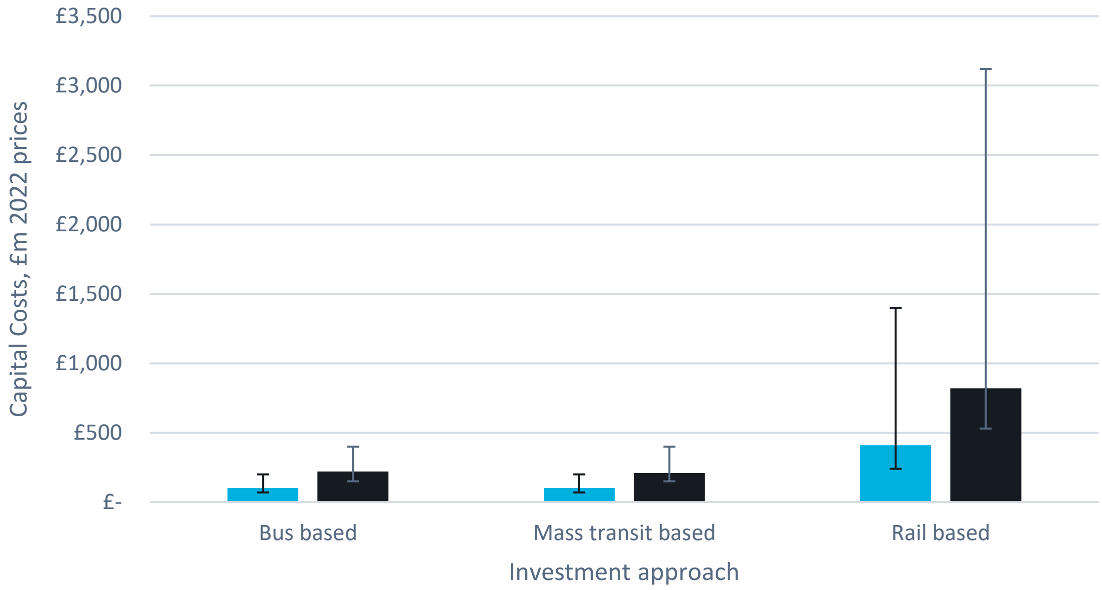
7.22 Costs are presented as totals for the 20 case study cities (the **blue** bars), and as totals for the group of the 54 largest towns and cities in England outside London (the **black** bars). Costs have been aggregated to the larger group based on treating the 20 cities as a sample, and extrapolating based on the average costs of investment in a small, medium and large-sized city respectively, and the number of cities (within the additional 34) within each size band.

7.23 Broadening the cost estimate from the 20 case study cities to the 54 increases the capital costs by circa 53% with the medium and high-capacity requirements, and by 110% with the low-capacity requirement. This latter result reflects how, with the low requirement, investment costs are more broadly spread across the different cities requiring capacity irrespective of size, whereas with the medium and high requirements, a large proportion of the cost is incurred for transformatory infrastructure in a small number of large cities. Since, of the additional 34 cities, only 2 are classified as large, this explains how the percentage difference in capital costs for the 20 cities versus the 54 varies between the different capacity requirements (and investment approaches).

Low-capacity requirement

7.24 A low-capacity requirement for English cities, with lower levels of employment growth within city centres combined with sustained, high levels of hybrid and remote working results in a small requirement for additional capacity across English cities. Of the 20 English cities studied in detail, only three are modelled to have a need for additional capacity compared to 2018, and the scale of this increase is modest (at circa 200, 1,200 and 2,500 people for each city).

Figure 7.6: Estimated capital costs by investment approach, for a low-capacity requirement in English cities (2022 prices)



7.25 Consequently, the capital costs of additional capacity under this scenario are very modest compared to the other capacity uplift scenarios, and pre-pandemic expectations. Figure 7.6 presents the estimated capital costs under each investment approach, and the error bars illustrate the broad range of uncertainty.

7.26 Capital costs with the bus-based and transit-based approach are small, at circa £220m for both approaches across the 54 cities, with a comparatively narrow range of uncertainty. This reflects that the scale of requirement can largely be met under these approaches by increased bus frequencies, longer or more frequent light rail services on existing networks, with only a very small (or no) requirement for additional fixed infrastructure.

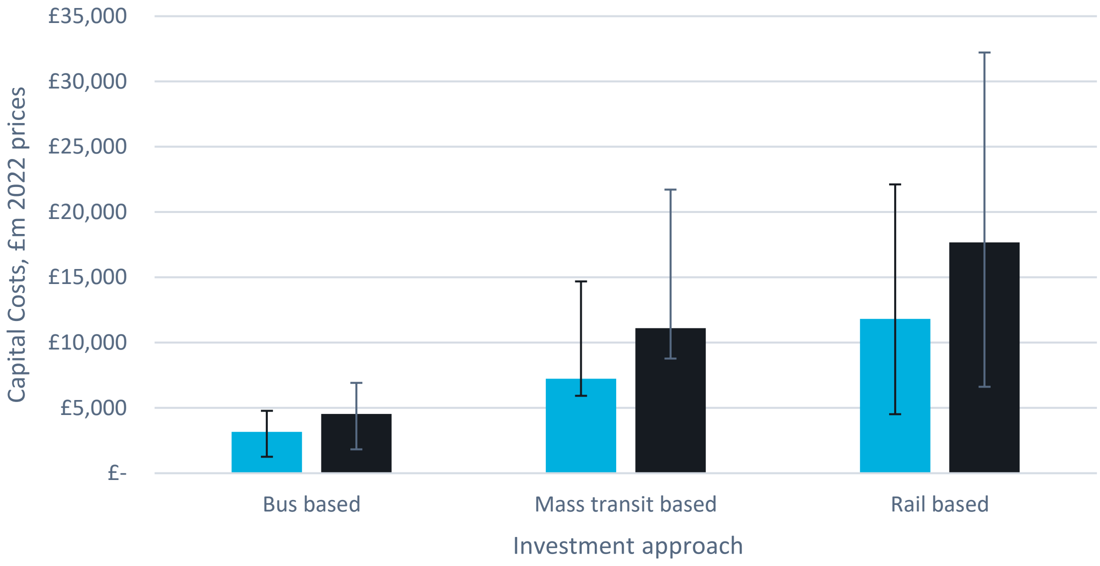
7.27 Costs for rail are estimated at circa £820m for the 54 cities, reflecting the likely need for platform lengthening, signalling enhancements and/or station upgrades in some cities to provide the required capacity uplift. However, reflecting the uncertainty in the scale of infrastructure required to increase rail capacity, the level of uncertainty is significantly greater than a bus-based or transit-based approach.

Medium capacity requirement

7.28 With the medium capacity requirement, where city centres broadly recover but with a reduced level of employment growth, and greater levels of homeworking compared to pre-pandemic trends, there is a materially greater requirement for investment. Of the 20 English cities studied in detail, six are expected to require additional capacity by 2055, and the scale of requirement per city typically in the range of 4,000 to 17,000 in the high peak hour.

7.29 For the three investment approaches, the capital costs associated with delivering this infrastructure are shown in Figure 7.7.

Figure 7.7: Estimated capital costs, by investment approach, for a medium-capacity requirement in English cities (2022 prices)



7.30 Across the 54 cities, capital costs are estimated at circa £5bn for a bus-based approach, £11bn for a transit-based approach and £18bn for a rail-based approach. This reflects:

- For a **bus-based approach**, additional capacity is provided through increased service frequencies and circa 40 km of bus priority measures and corridor improvements in each city at relatively modest capital cost. Achieving this uplift in capacity in the largest cities is likely to require more efficient operating practices, such as double-door operation and simpler fares and ticketing, to reduce dwell times and enable more services to operate within existing street constraints. There is a risk that, for those cities with higher capacity requirements, increasing bus capacity in this way will not be feasible and that mass transit infrastructure is required at additional cost;
- For a **transit-based approach**, additional capacity is provided through new and expanded light rail networks in each city, except the smallest where additional capacity is provided by bus. The high upper end cost uncertainty reflects the uncertainty in the scale of additional tram network assumed in the different cities, and whether new cross-city centre tram lines (potentially tunnelled) are required in the largest cities to alleviate physical constraints;
- For **a rail-based approach**, additional capacity is provided through a combination of platform lengthening, signalling enhancements and station upgrades. Again, the scale of uncertainty reflects the uncertainty regarding the requirement for high-cost interventions to alleviate city centre pinch-points on the rail network.

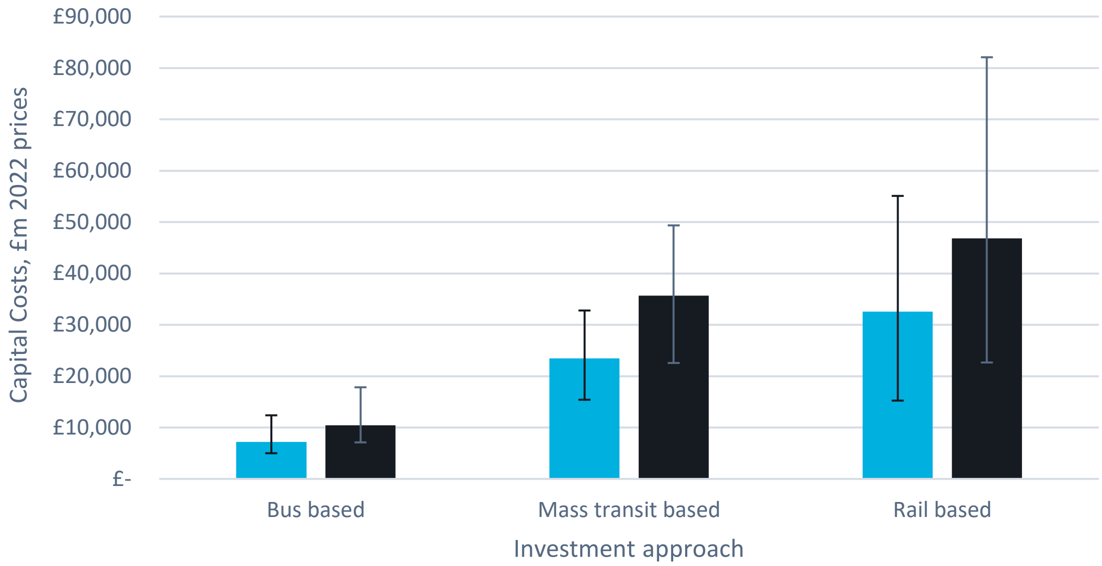
High capacity requirement

7.31 With the high-capacity requirement, where city centres rebound strongly post-pandemic, and increased city centre employment counteracts increased levels of homeworking, the level of investment is comparable to what could have been expected pre-pandemic.

7.32 Here, of the 20 English cities studied in detail, eight are expected to require additional capacity by 2055, and some cities have very high requirements. Three cities have a requirement of circa 1,500 – 2,000, and the others a requirement of 32,000, 22,000, 16,000, 11,000 and 9,000.

7.33 The capital costs under the three investment approaches, associated with delivering this infrastructure are shown in Figure 7.8.

Figure 7.8: Estimated capital costs, by investment approach, for a high-capacity requirement in English cities (2022 prices)



7.34 The capital costs of providing this scale of increase are substantial, from circa £36bn for a transit-based approach and £47bn for a rail-based approach, with a wide range of potential uncertainty. This cost uncertainty reflects the significant uncertainty in the scale of additional infrastructure that would be required to deliver large capacity increases (20,000+ people in the high peak hour) within a small number of cities, and in particular:

- For a **transit-based approach**, the extent to which capacity can be increased through expansion and continued incremental development of existing light rail networks, new city centre light rail tunnels and/or (as a very high-cost solution) new urban metro type systems (e.g. similar to the Docklands Light Railway) in the largest cities;
- For a **rail-based approach**, the extent to which capacity can also be increased largely within the constraints of the existing rail network (e.g. train and platform lengthening, high-density rolling stock, signalling upgrades and more frequent trains, expanded city centre terminal stations) versus major new underground Crossrail-type infrastructure, and the geographical scale over which it is provided.

7.35 The ability for committed HS2 investment, by moving some 'inter-city' demand off the existing rail network within Birmingham and Manchester and hence releasing capacity for more local journeys, has also not been assessed but could reduce the infrastructure requirements and capital costs for these cities on some specific corridors. Similarly, should Northern Powerhouse Rail be delivered, as currently proposed within the DfT's Integrated Rail Plan, this would further reduce the additional infrastructure requirement and capital costs by both providing commuter capacity directly and by allowing local rail capacity within Liverpool, Manchester, Leeds and Newcastle to be repurposed.

7.36 A bus-based approach has been costed, but is not shown on the graph as in our view is likely to be undeliverable in practice. Within the largest cities, practical, physical constraints (e.g. on kerb space) will limit how many additional bus services can access city centres and hence the required scale of increase in capacity required. While a combination of larger vehicles, double door operation and simpler fare structures could result in a meaningful increase in capacity compared to today, it is unrealistic to assume this could meet the scale of requirements envisaged in the largest cities.

7.37 Although developing a plausible, low-cost, bus-based approach for developing a large increase in city centre capacity may be technically possible, it would be highly context-specific and outside the scope of this study.

Suburbanisation effects

7.38 Chapter 4 discussed the potential implications of individuals moving to more suburban locations, and commuting longer distances to city centre locations, on total distance travelled and demand by mode.

7.39 If these effects occur, it would result in a need for more medium and longer-distance public transport capacity was identified, with a reduced role for active travel. Compared with a continuation of existing trends, greater suburbanisation is likely to lead to:

- a reduced requirement for **local bus** capacity and connectivity;
- an increased requirement for **rail**, especially connectivity to and from small commuter towns and rural hinterlands surrounding large cities (where this can feasibly be provided);
- an increased requirement for **metro, tram and/or high-quality BRT services** that provide journey times and reliability competitive with private car from suburban locations to city centres (typically greater distances than local bus journeys);
- an increased requirement for **park-and-ride connectivity**, and/or **'first-last' mile solutions**, to rail, metro, tram and/or BRT stops and stations.

7.40 Since the overall change in demand by mode was estimated to be relatively modest, and vary significantly for each city, we have not separately costed the effects of providing more suburban capacity over longer distances. However, it should be noted that if suburbanisation effects occur in practice:

- a bus-based approach to providing capacity is less well-suited to patterns of travel demand, as it is less attractive compared to rail-based modes for longer-distance travel and connectivity to suburban areas. However, express bus services and park-and-ride connectivity do still provide a potential, lower cost option to providing increased capacity to suburban areas;
- mass-transit and/or rail-based approaches tend to be better suited to providing medium and longer-distance connectivity to suburban areas, but at greater capital cost. Even with these modes, the reduced density of suburban areas is likely to mean a need for connecting bus services, park-and-ride and 'first-last' mile connectivity as fewer people will reside within an immediate walk catchment;
- the capital costs of supporting longer-distance commuting patterns are unlikely to be materially different that as presented in Figure 7.6 to Figure 7.8. The capital costs for transit already assume new light rail lines extend to the edges of urban areas; for rail, the majority of the cost in incurred in providing additional city centre capacity, and the distances services operate across is of less relevance (i.e. the cost is to operate more trains, irrespective of where they depart from);
- a potential exception to this is where the rail network is expanded with new lines to suburban areas and commuter towns. This will be dependent on the existing geography of the rail network in each city, and the extent to which commuter towns are already

integrated within it. However, the cost of new lines can be assumed to be included within the 'higher bound' of cost uncertainty for the rail-based investment approach presented in in Figure 7.6 to Figure 7.8, which reflects a 'pessimistic' view for the level of infrastructure (and hence cost) required for a given uplift in capacity.

Implications for revenue and subsidy requirements

7.41 We have also explored the potential annual fare revenue, subsidy requirements and hence operating costs for the additional public transport envisaged under the different capacity uplift scenarios. However, it should be highlighted that this is challenging and practice the outputs highly uncertain, as discussed below.

Challenges and Limitations

7.42 Operating costs for public transport – and especially for rail – do not directly scale to demand. A bus or rail service, for example, will cost a similar amount to operate irrespective of how many people it is carrying, and how much fare revenue they generate.

7.43 There are also significant efficiencies of scale in operating costs, especially for rail, with longer trains carrying greater volumes of people with a disproportionate increase in operating costs when compared to the scale of capacity uplift. This partly explains, for example, why the scale of rail subsidy 'per passenger km' varies so significantly nationally – from 2p per km for Govia Thameslink Railway services in the South East, compared to 24p and 30p per km for Merseyrail and Northern services respectively.[33]

7.44 The focus of our study, and our modelling up to this point, is assessing future city centre transport demand and infrastructure requirements in the **high peak hour** only. This is appropriate for determining potential capital costs as peak-hour demand is typically used to plan and 'scale' a city centre transport network, as the infrastructure must broadly cater for demand at the busiest times.

7.45 However, when considering annual revenue and ongoing subsidy, it is all-day (and all-week) demand which is most relevant. Greater provision of public transport infrastructure to match a peak-hour requirement will typically result in more frequent and/or new services operating all day,[34] and while services will be heavily used during the peak hour, the overall revenue and subsidy position will hence be largely determined by to two key factors:

- the scale of increased demand in the shoulder and inter-peak periods, where most demand occurs;
- the extent to which additional capacity is provided at marginal cost (e.g. lengthening trains) versus new services and infrastructure (new light rail networks or rail services).

[33] 2018/19 data and prices, from ORR Table 7273: Government subsidy by franchised passenger operator (up to 2018-19) and Table 1233: Passenger kilometres by operator, Great Britain, April 2011 to September 2022.

[34] In a UK context, the marginal cost of running off-peak services is sufficiently small (since the rolling stock and infrastructure has scaled to meet peak-time demand) to justify high service frequencies, and only a small reduction compared to the peak. However, this is not universally the case – for example in North America many rail commuter services only operate during peak periods and the infrastructure and rolling stock is largely unused during the middle of the day.

7.46 Both these factors have a material effect on the total revenue and potential future subsidy requirement. If demand is better distributed across the day, this will likely reduce operating subsidy (at least on a per journey basis, and potentially in absolute terms); conversely, if demand becomes more peaky, the opposite will occur.

Approach

7.47 Since our study has been focused solely on high peak hour commuting demand, which only makes up a subset of overall trips to city centres, and we have not stipulated the exact type of infrastructure enhancements within each city, it is therefore difficult to robustly assess potential annual revenue and subsidy. Our simplifying assumptions are:

- each new commuting trip results in additional trips (of all purposes) in the shoulder and off-peak periods, broadly in line with that pre-pandemic;[35]
- all these new trips generate fare revenue, and a subsidy requirement, in line with the scale of 'per trip' revenue and subsidy pre-pandemic for that mode;[36]
- no real changes in operating costs versus revenue are assumed (in recent decades, across public transport, operating costs per passenger have typically increased more than fare revenue).

7.48 In effect, this assumes that revenue and subsidy follow pre-pandemic trends – an increase in peak demand occurs alongside that in the off-peak; the fundamental cost of operating bus and rail services per passenger does not change. Without a model of all-day operating costs, it is difficult to test the sensitivity to these assumptions.

7.49 The balance of revenue versus subsidy, and total operating cost, is also highly dependent on local fare structures. For example, generally within metropolitan areas outside of London, rail fares are relatively low per km compared to bus, in contrast to within London where the opposite is true. Changes to fare structures and overall fare levels will therefore also materially influence long-term subsidy requirements.

Potential revenue and subsidy requirements per scenario

7.50 Figure 7.9 summarises the potential scale of operating cost, and the balance between subsidy versus fare revenue, for each of the nine capacity uplift scenarios. It is intended to highlight the broad scale of potential subsidy requirements, noting the significant uncertainties in projecting revenues versus operating costs. Note that:

- Each of the three sets of bars refers to a specific investment approach – bus-based; transit-based and rail-based;
- Within each set, the **blue** bars relates to the costs associated with a 'low' capacity requirement, the **orange** a 'medium' requirement and the **black** the 'large';

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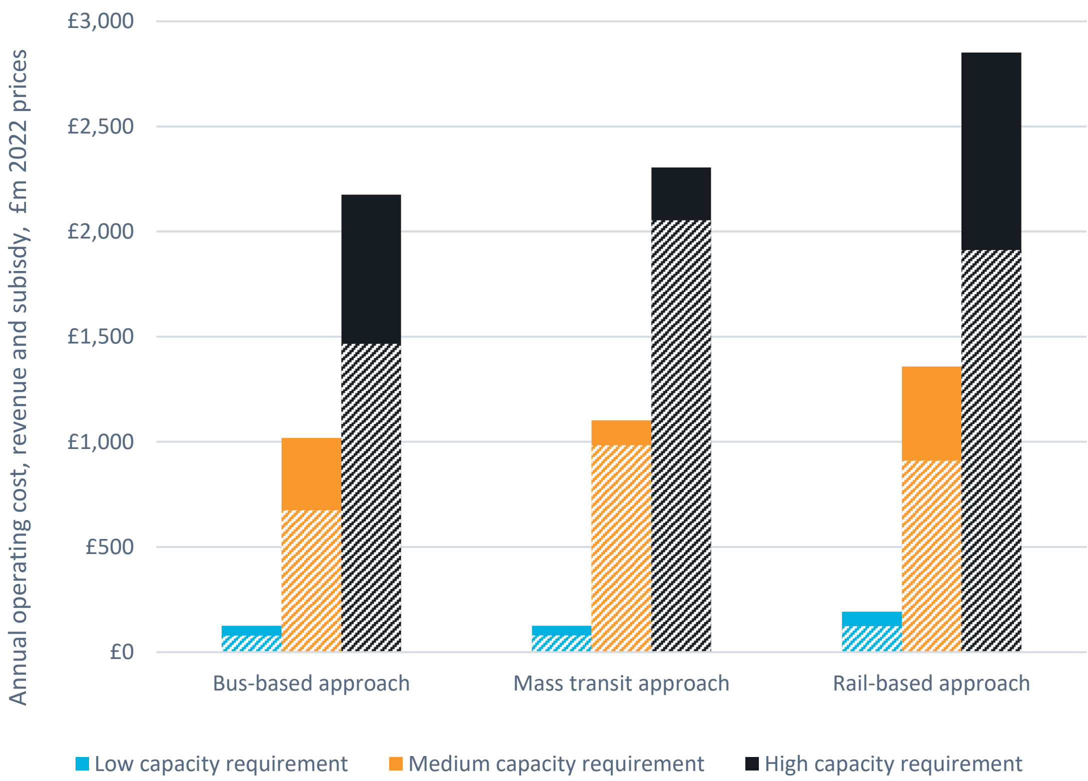
[35] This equates to increasing total revenue and operating cost by an 'annualisation factor' of circa 3,000 for rail and 6,000 for bus and tram to convert from high peak hour to annual demand, revenue and subsidy, informed by count data.

[36] For example, a 2018/19 bus trip in a UK metropolitan area typically 'cost' £1.39 to operate (annual operating costs divided by passenger numbers), of which circa 84p was funded through fares and 55p from some type of Government subsidy or financial support (e.g. Public Transport Support, Bus Service Operators Grant and Concessionary Travel Reimbursement)

- The total height of the bar represents the total estimated operating costs of the additional infrastructure assumed. Within this, the shaded area represents the operating cost funded through fare revenue, and the solid area of the bar the estimated subsidy requirement.

7.51 Note that subsidy and revenue is only assessed for those cities that require additional capacity; we have not considered the additional revenue, and likely reduction in subsidy, of additional patronage on existing transport networks where there is no increase in capacity.

Figure 7.9: Estimated additional operating cost, revenue and subsidy requirements, by scenario, 2022 prices



7.52 Clearly, the scale of additional operating costs (together with revenue and subsidy) increases materially as the capacity requirements increase, from circa £120 - 190m with the low requirement to £2.2 - 2.9bn with the high requirement, irrespective of the investment approach. This reflects the significant increase in the scale of additional infrastructure provided as the capacity requirement increases. These figures compare against total GB-wide bus industry revenue (both fares and Government support) of circa £6bn, and GB rail expenditure of circa £21bn, in 2019/20.[37]

7.53 With the medium capacity requirement, total operating cost ranges from £1.0bn with the 'bus-based' investment approach to £1.1bn for transit-based and £1.4bn for rail-based. The subsidy requirement is smallest for mass transit, then bus, then rail. This reflects the current level of subsidy per passenger journey on different modes pre-pandemic.

7.54 With the large capacity requirement, total operating cost ranges from £2.2bn with the bus-based investment approach to £2.3bn for a transit-based approach and £2.8bn for a rail-based approach. Total additional subsidy requirements range from £700m for bus-based, £300m for

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[37] DfT Bus Statistics Table BUS04ai; ORR Rail Statistics Table 7210

transit-based and £900m for a rail-based approach. This compares to pre-pandemic, 2019-20 Government support for the GB bus industry of circa £2bn (through Gross Public Transport Support, Concessionary Travel and Bus Service Operators Grant) and for the rail industry of circa £7bn.[38]

Demand management revenue and cost assessment

7.55 We have also explored the potential annual revenue, and operating costs, that a cordon-based congestion charge and/or workplace parking levy could realise within the 20 case study cities.

Cordon-based congestion charging

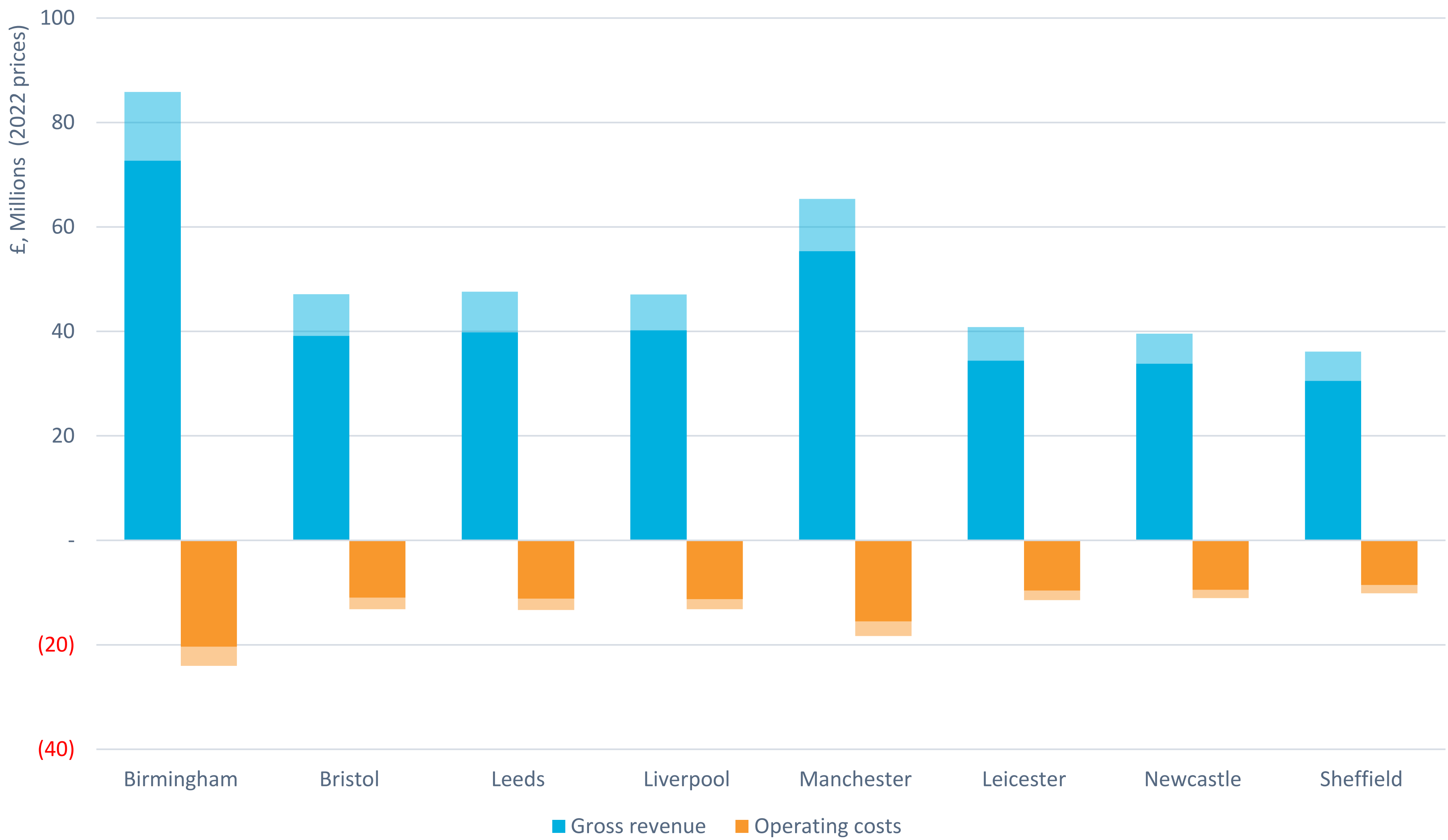
7.56 We have assessed the high-level revenue, capital and operating costs of introducing a cordon charging system within the eight 'large' cities where charging is considered feasible.

7.57 This is based on an assumed £5 a day charge per vehicle, with exceptions similar to that in London, and the 'medium' assumptions for the reduction in traffic and mode shift as set out in Paragraph 6.29. The geography assumed for the cordon charging is generally tightly defined around an inner-city ring road and matches the city centres employment cordons. It should be highlighted that the revenues would be materially greater if implemented across a wider geography, such as the proposed Cambridge scheme, and those proposed in Manchester and Edinburgh in the late 2000s.

7.58 Figure 7.10 illustrates the potential annual gross revenue and operating costs of a cordon-based congestion charging scheme within 'large' cities, with the scale of the range accounting for potential downside effects of homeworking and business centralisation trends on commuting intensity, and/or a higher level of reduction in traffic crossing the cordon.

[38] DfT Bus Statistics Table BUS05ai; ORR Rail Statistics Table 7210

Figure 7.10: Estimated gross revenue and operating costs, eight 'large' case study cities



7.59 This indicates the potential for net revenues (including gross charge revenue and operating costs) of circa £50 - 60m per annum for Birmingham, £40m for Manchester and £30m for cities like Leeds, Bristol or Liverpool, all in 2022 prices. By way of contract, the revenue of the London Congestion Charge (and ULEZ) in 2019/20 was £247m.[39] Its operating costs were £85m, leaving a net position of £162m.[40]

7.60 The costs of development and implementation largely scale to the geographic size of the scheme and have been estimated based on the London Congestion Charge. Implementation costs are estimated at circa £60-70m for Sheffield or Newcastle and £140-150m for Birmingham[41].

Workplace Parking Levy

7.61 We have assessed the high-level revenue, capital and operating costs of introducing a Workplace Parking Levy across the 20 case study cities. This assumes a levy similar to that delivered in Nottingham and under development elsewhere. The levy is applied within the local authority boundary to workplace parking only. This is a significantly broader geography compared to the city centre-based cordon charging described above.

7.62 Figure 7.11 shows the indicative potential annual gross revenue and operating costs of a workplace parking levy scheme on the case study cities, with ranges accounting for the potential effects of homeworking and business centralisation trends on commuting intensity.

7.63 It illustrates the potential for net revenues (including gross charge revenue and operating costs) of circa £25-30m per annum for Birmingham or Leeds and £15-20m for other large cities such as Bristol and Manchester, all in 2022 prices. A 'medium' sized city like Coventry could potentially have annual net WPL revenues of around £10m, while a 'small' city like Norwich would be around the £5m mark.

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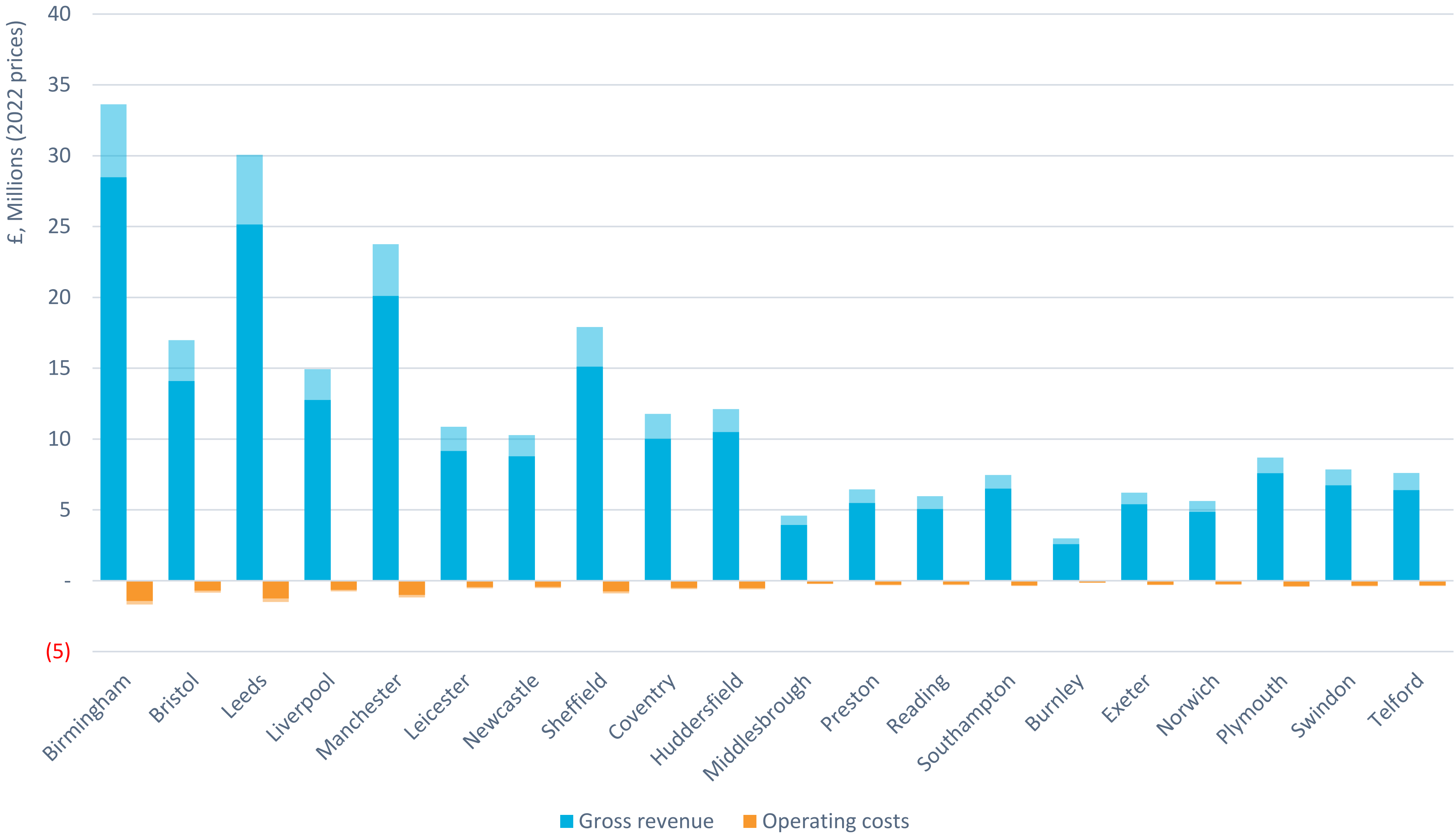
[39] Other than the last few weeks of 2019/20, this year was unaffected by the pandemic. In 2019/20, the charge was £11.50; it increased to £15 in June 2020.

[40] Transport for London (2020) '**Annual Report and Statement of Accounts 2019/20**', page 123

[41] Note this does not include any potential efficiencies where cities already have existing ANPR infrastructure for other charging systems (e.g. Birmingham's Clean Air Zone)

Figure 7.11: Estimated workplace parking levy gross revenue and operating costs, 20 case study cities



7.64 It should be highlighted that the workplace parking levy assessment has been undertaken at an LAD level, which may not always reflect a practical or ideal geography for such a charge to be introduced. This is particularly the case within Huddersfield, where the LAD geography (Kirklees) also includes a wider rural area and several free-standing towns such as Dewsbury.

7.65 The costs of development and implementation of the WPL would be directly related to the size of the scheme and have been calculated using available data from Nottingham. They are expected to range from £1-2m for smaller cities like Norwich to £8-10m for Birmingham, the largest city and LAD.

Physical demand management

7.66 A physical approach to demand management would not include raising revenue as a direct objective (although an ANPR-led approach would be likely to yield some revenue from non-compliance).

7.67 The cost of physical demand management would vary significantly based on the scale of the scheme, the number and type of filters (e.g. physical bollards versus ANPR cameras) and any complementary measures to physically re-allocate road space or reconfigure streets (e.g. new cycling infrastructure or urban realm improvements. The proposed trial scheme in Oxford, with six traffic filters enforced by ANPR, is reported to cost:[42]

- circa £6.5m to introduce (including ANPR cameras, associated infrastructure, legal consents and consultation);
- annual maintenance, enforcement, signs and road markings costs of £150,000;
- annual back-office and communications costs of £300,000;
- potential penalty revenue from driver non-compliance of £1.1m annually.

[42] BBC News, **"Oxford's £6.5m traffic filter trial set to be approved"**, 22 November 2022

A City Centre cordon definition and maps

Cordon definition

A.1 City centre cordons have been defined with the overarching aim of capturing areas of high employment while also considering the effect of current transport infrastructure on the boundaries of the city. Cordon definitions therefore consider both employment and natural/man-made barriers to movement.

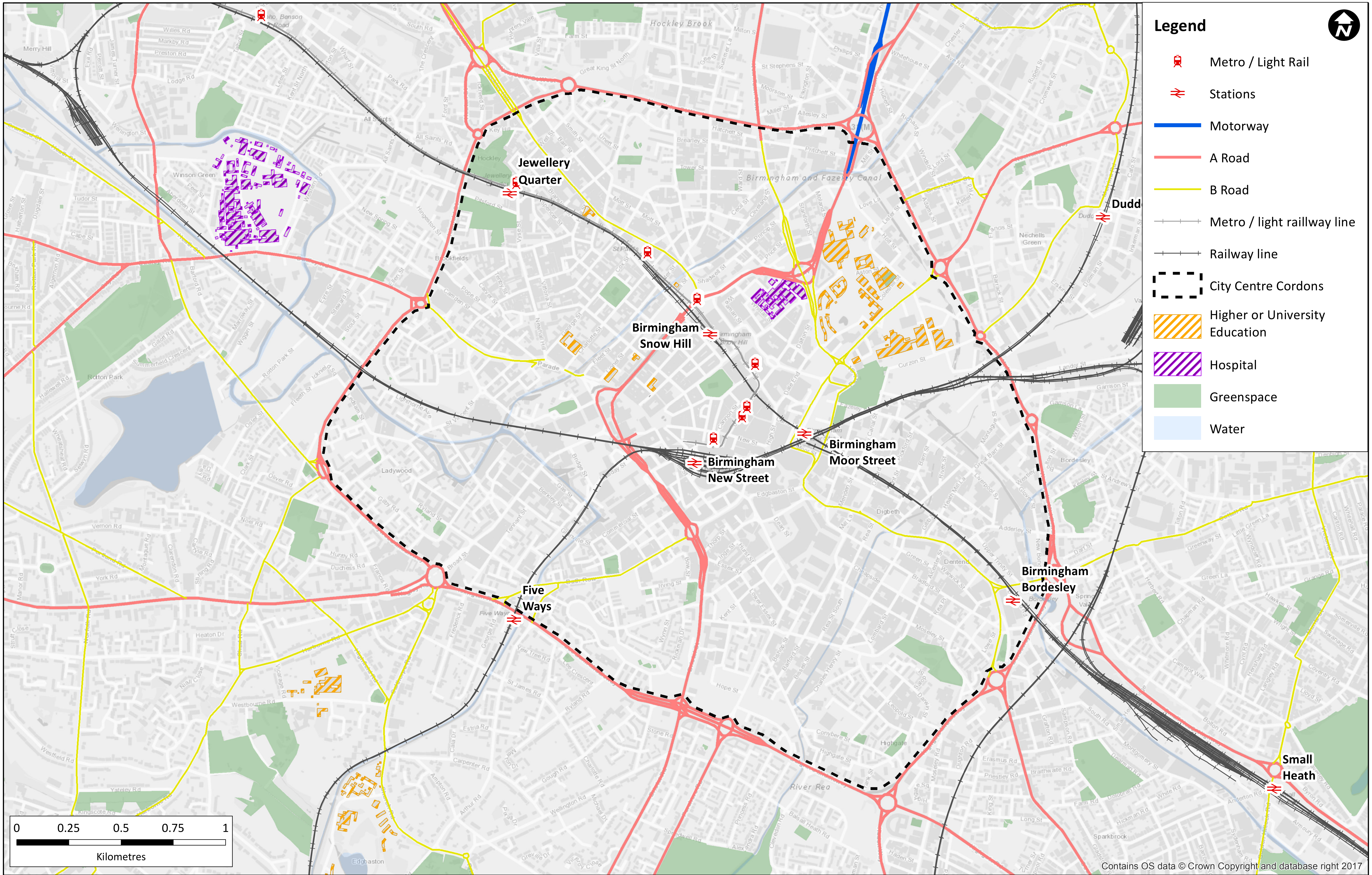
A.2 In most cases, the cordons are defined tightly around the central business districts of case-study cities. They match those adopted in the previous 2018 study.

A.3 Census workplace population data is used to identify areas with the highest concentration of employment. Barriers to movement result in limited crossing points and include, for example, railways, rivers, canals, ring roads, grade-separated roads, parks, etc.

A.4 Some consideration has been given to aligning city centre cordons with ONS geographic boundaries, however this is not always appropriate as ONS geographic boundaries (e.g. MSOAs) are defined such that they have similar levels of population, not employment, which means that they can be large in areas of low residential population density such as city centres.

Cordon maps

A.5 City centre cordon maps are provided on the following pages. Note that where a city's principal rail station falls outside the cordon, rail capacity to the station has been included within the capacity calculations. All case-study cities have rail stations.



National Infrastructure Commission Capacity Review

Birmingham

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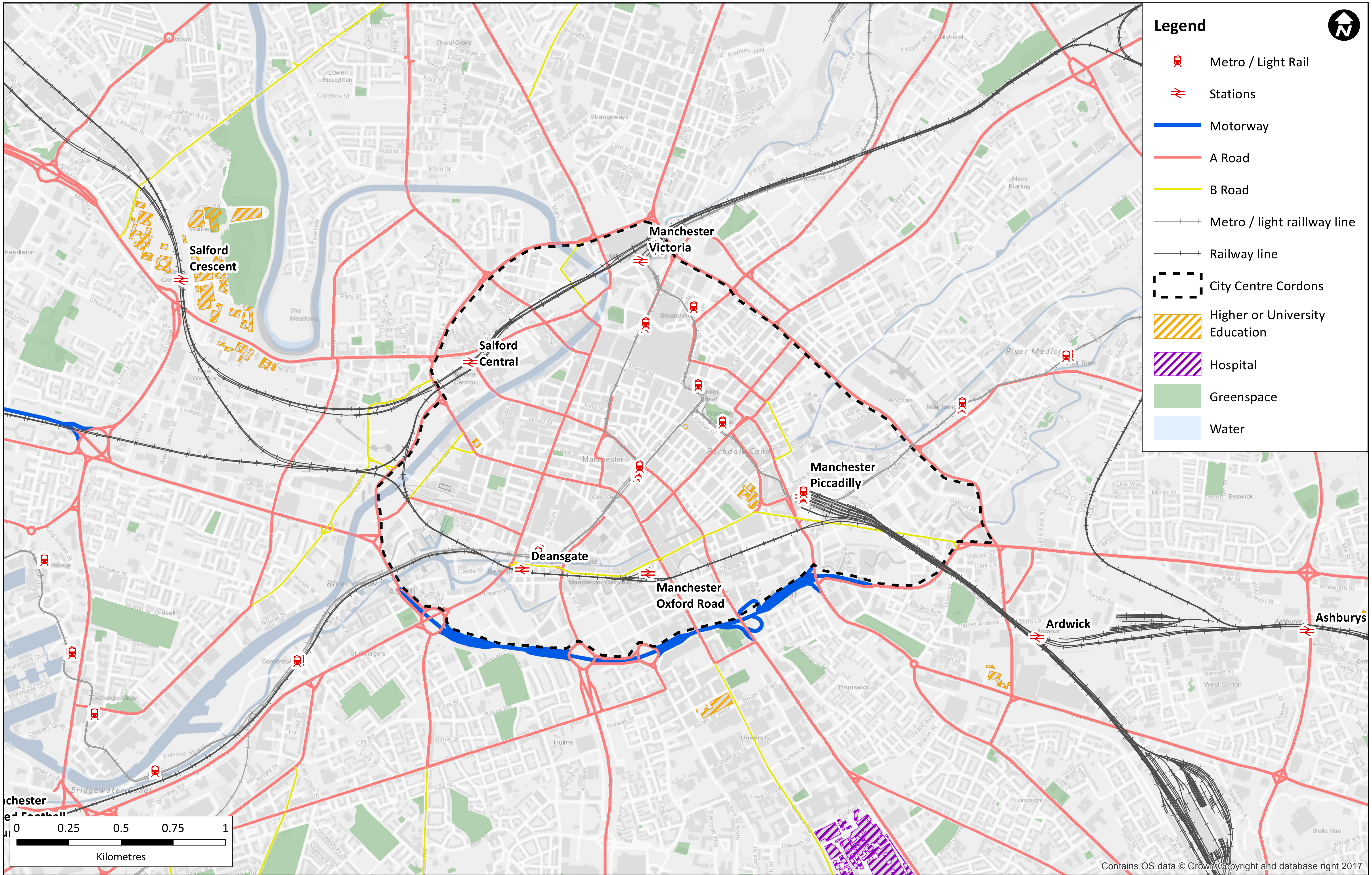

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Manchester

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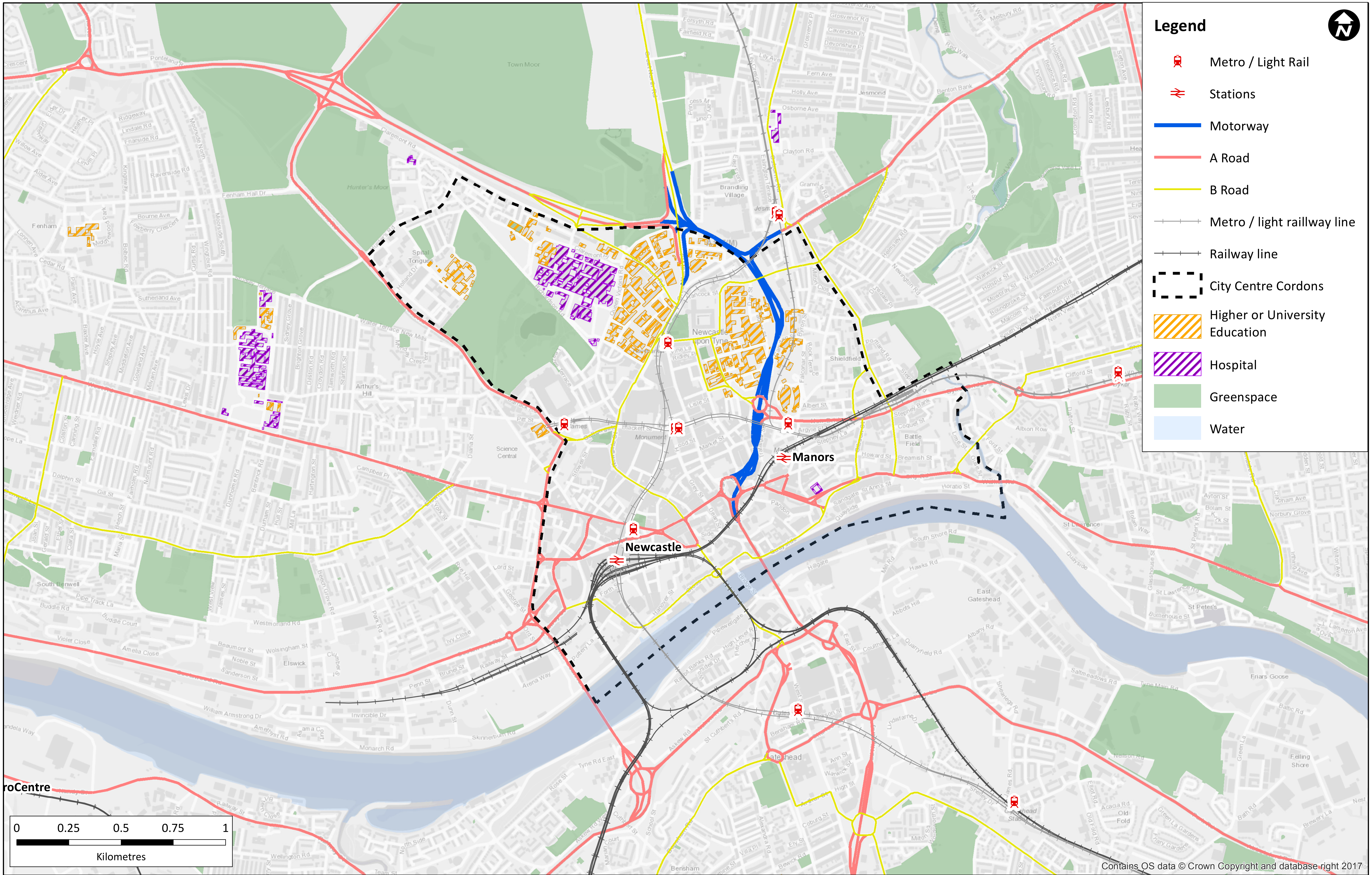

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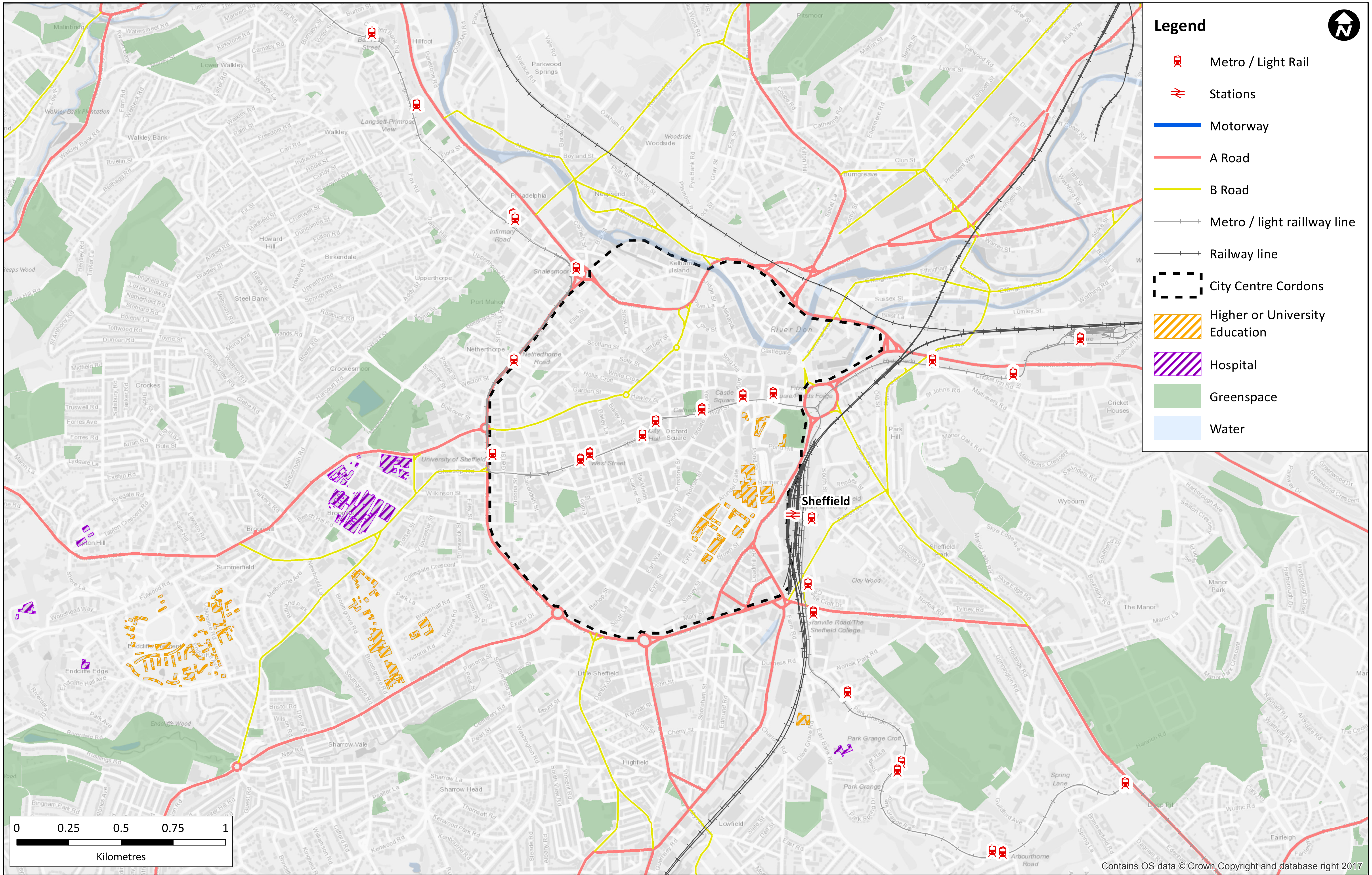

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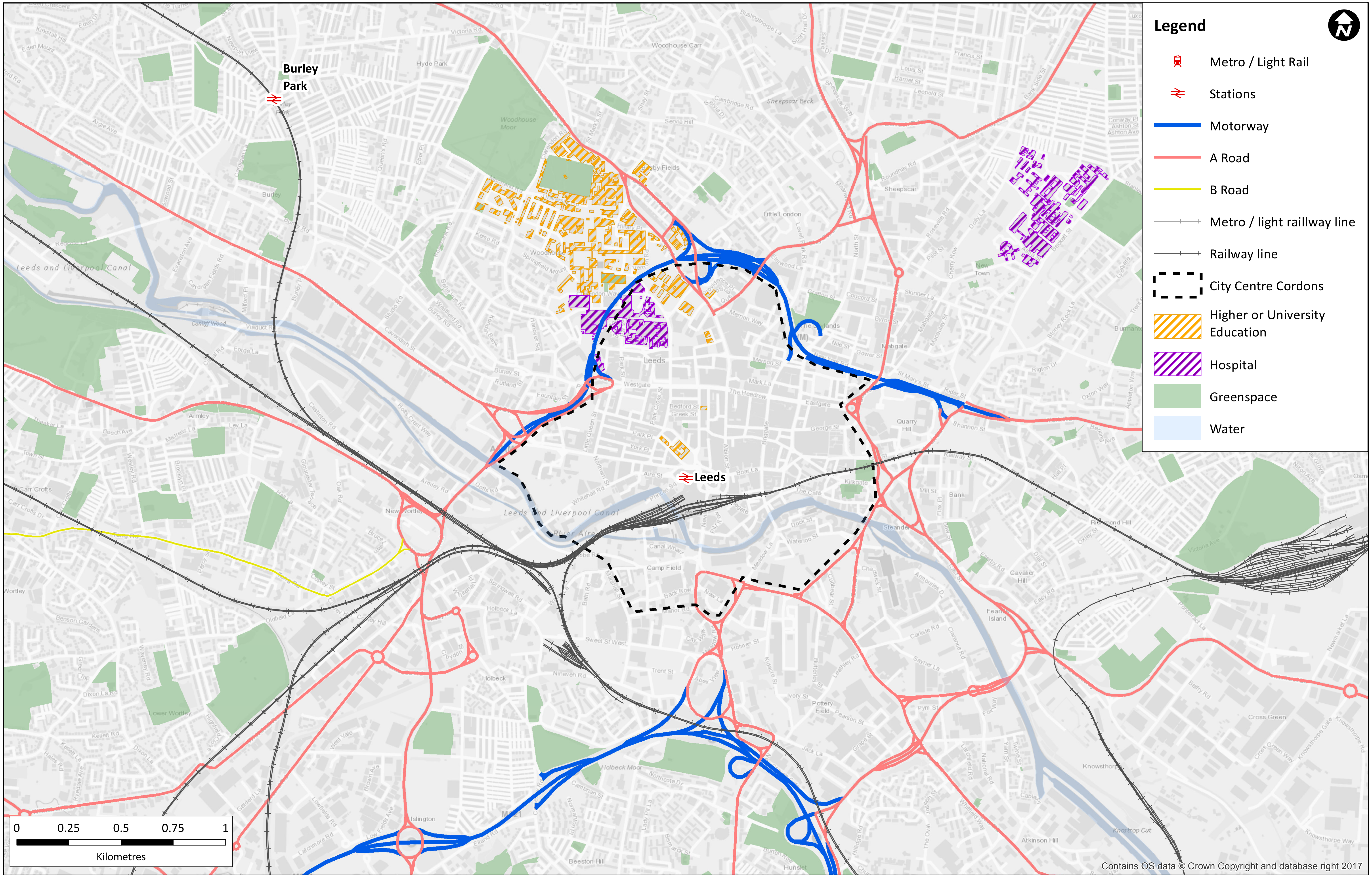

National Infrastructure Commission Capacity Review

Leeds

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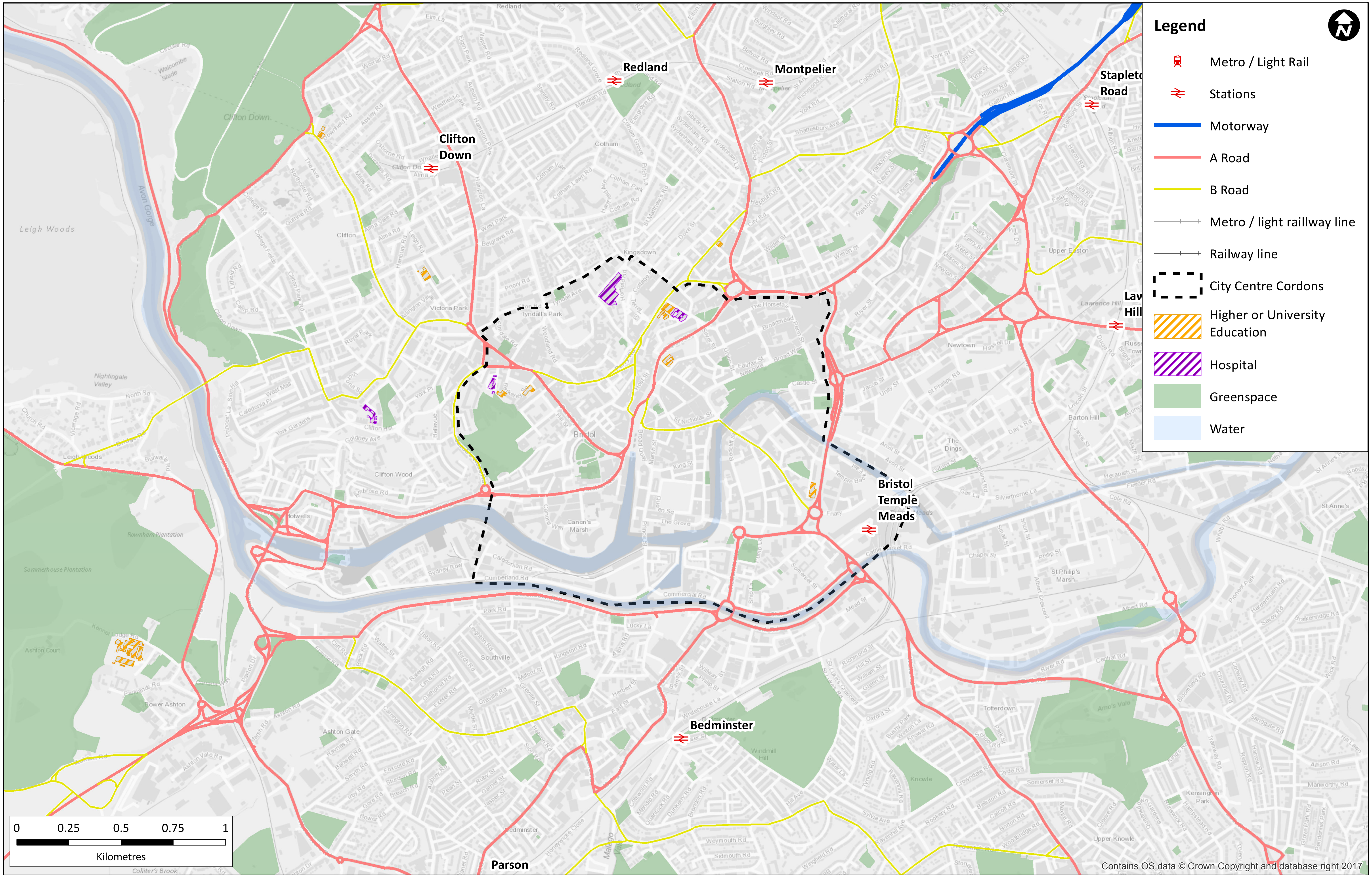

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Bristol

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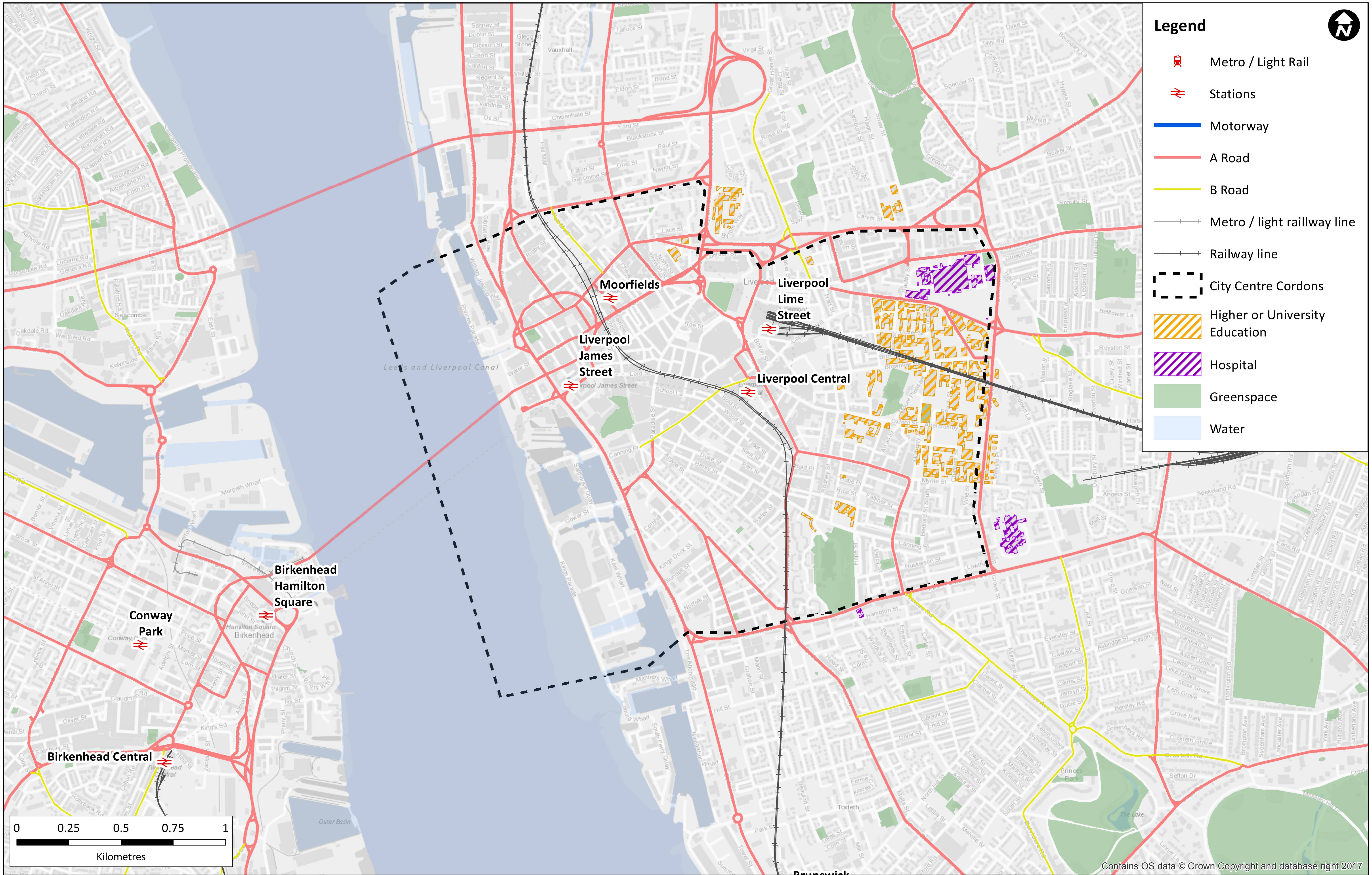

National Infrastructure Commission Capacity Review

Liverpool

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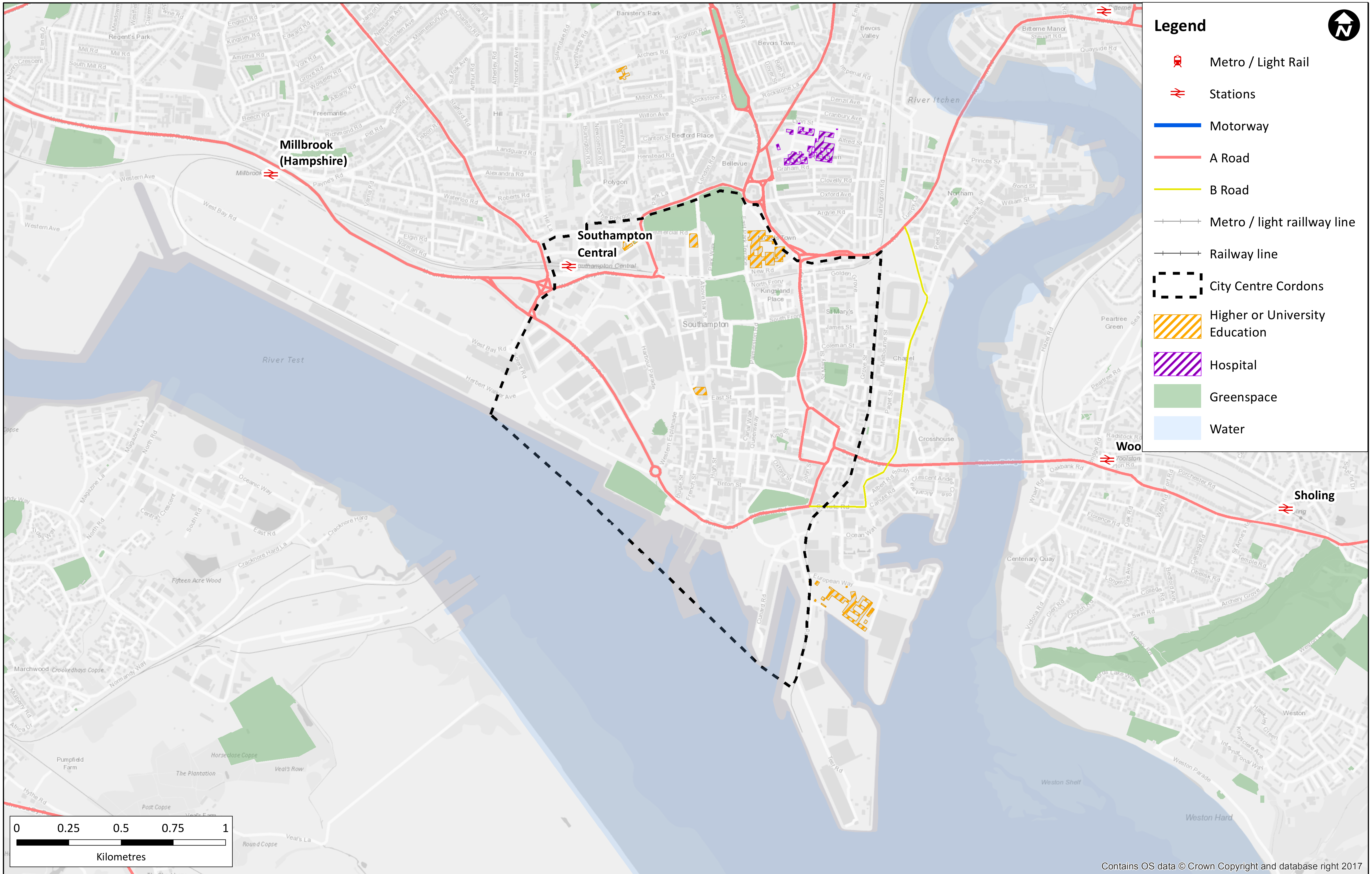

National Infrastructure Commission Capacity Review

Southampton

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Created by:	Last Updated:	Scale:
ORussell	23/02/2018	16,000

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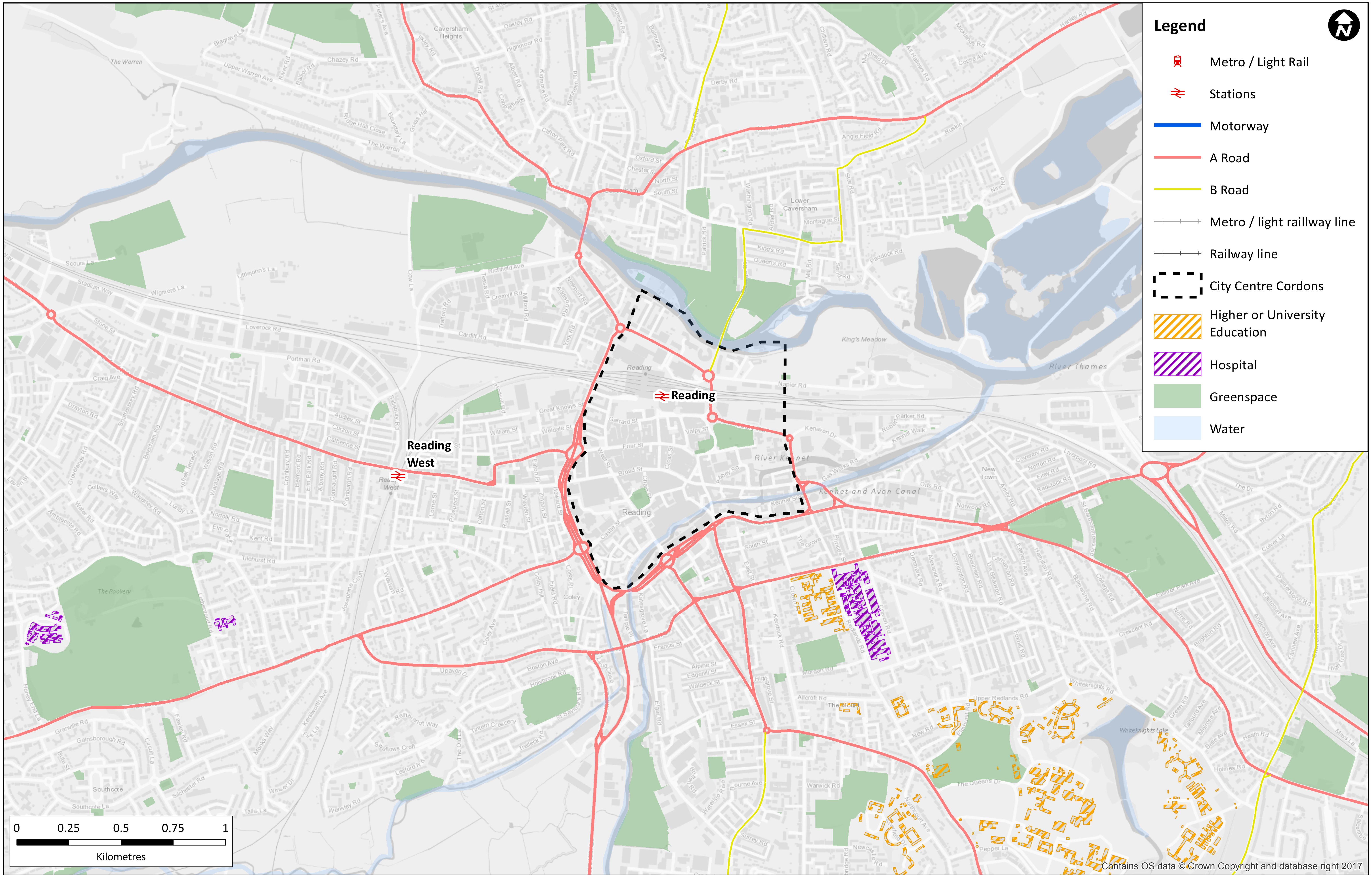

National Infrastructure Commission Capacity Review

Reading

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ORussell	23/02/2018	16,000

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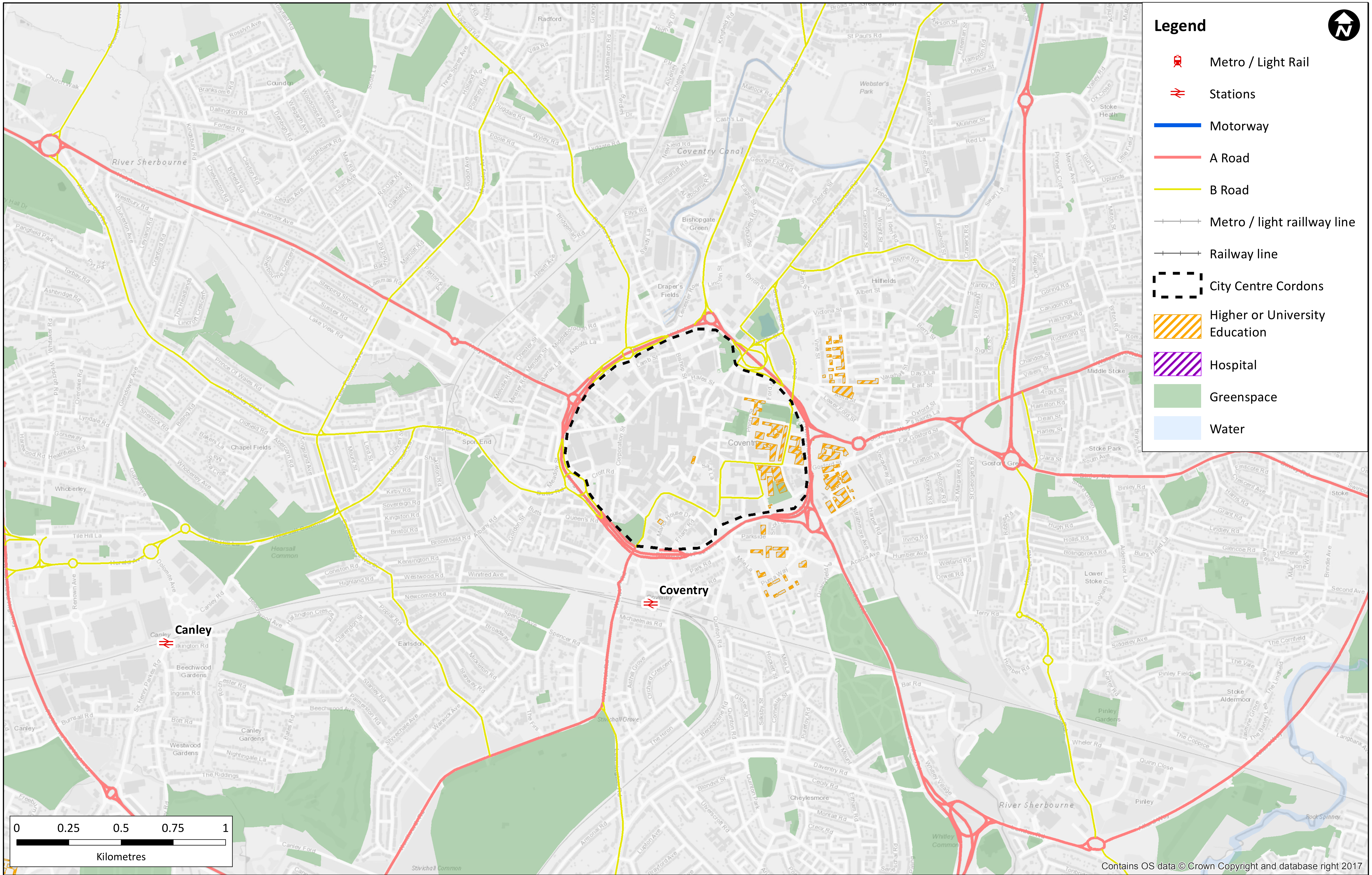

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Coventry

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ORussell	23/02/2018	16,000

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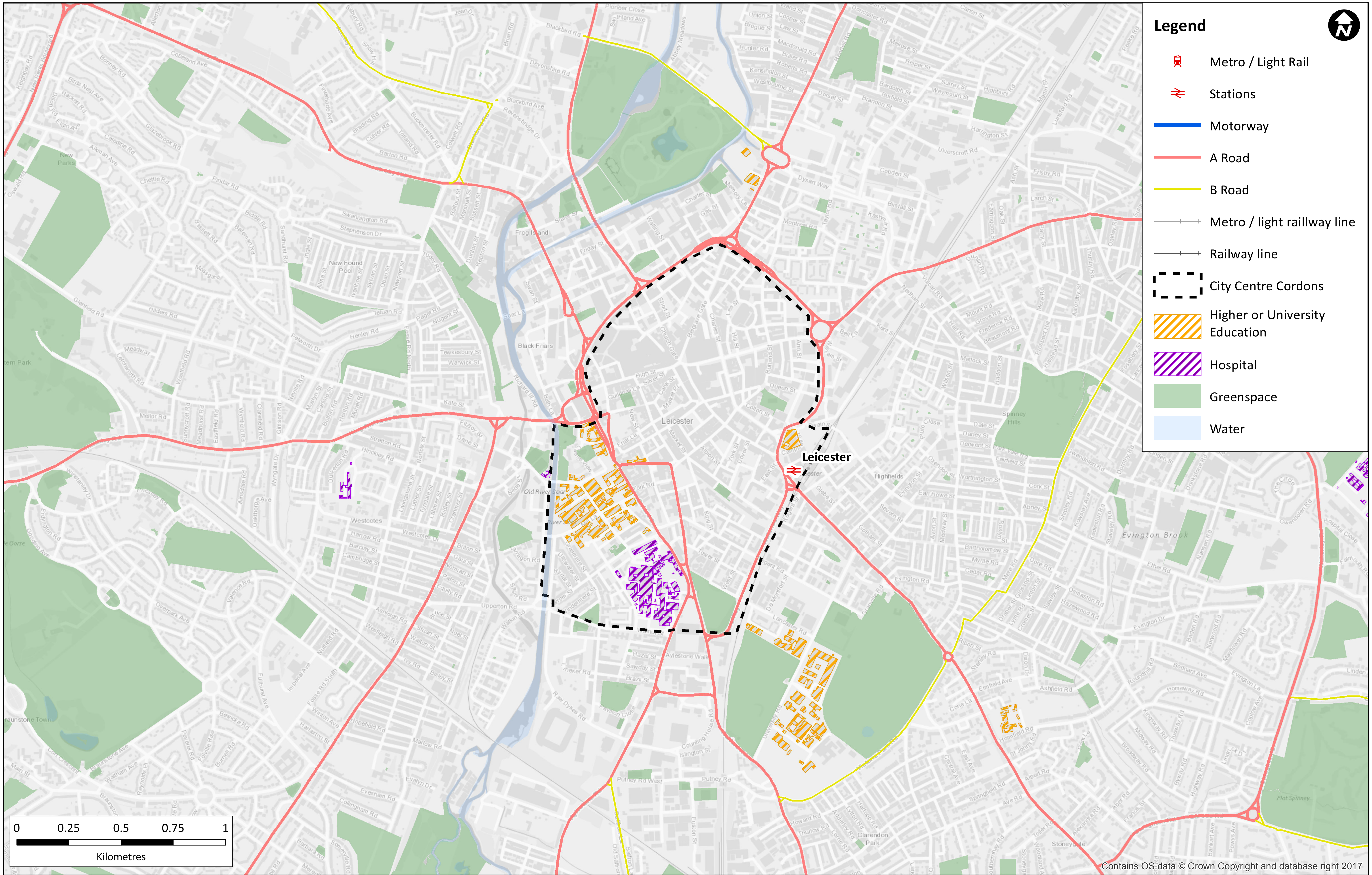

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Leicester

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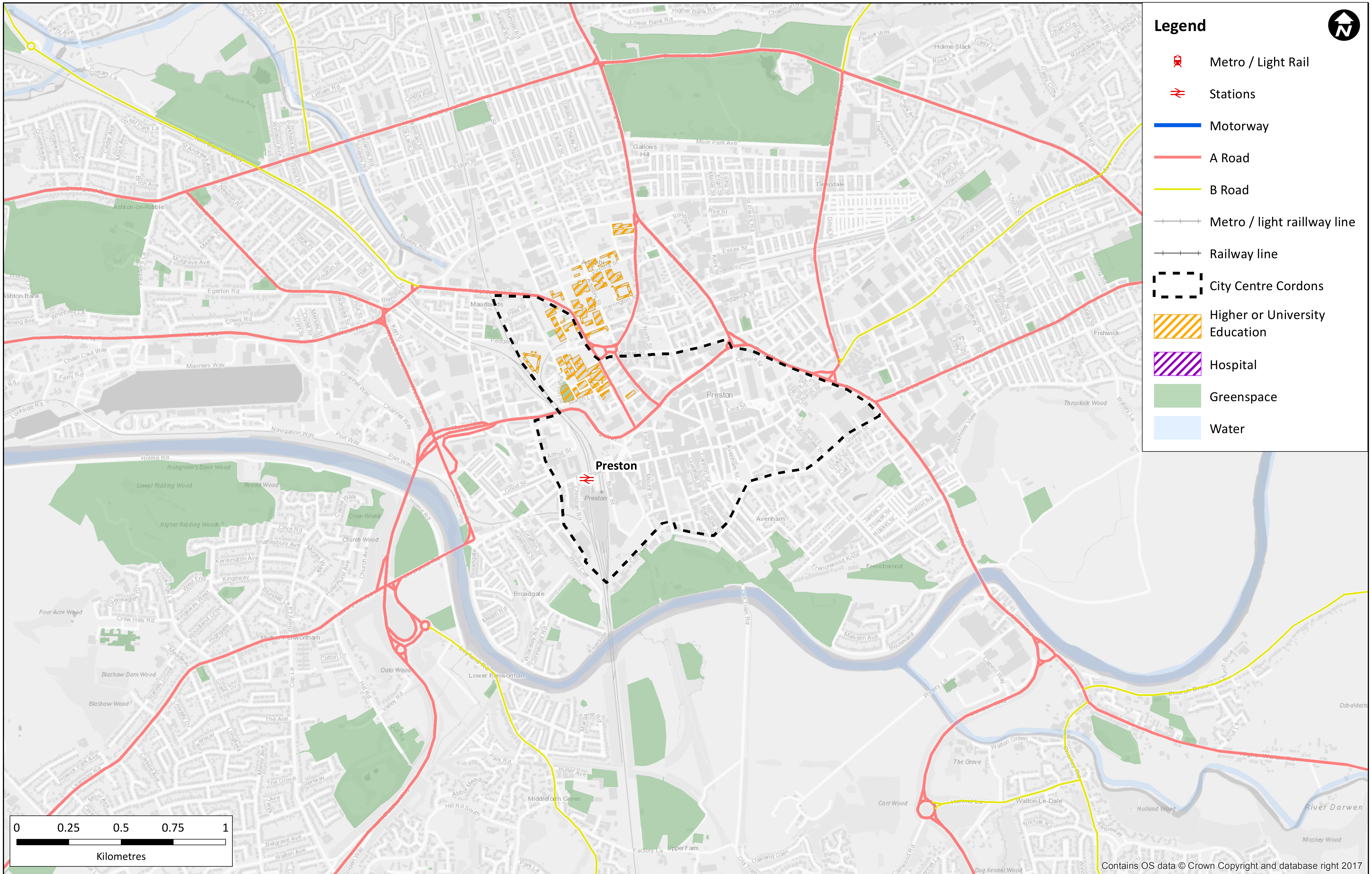

National Infrastructure Commission Capacity Review

Preston

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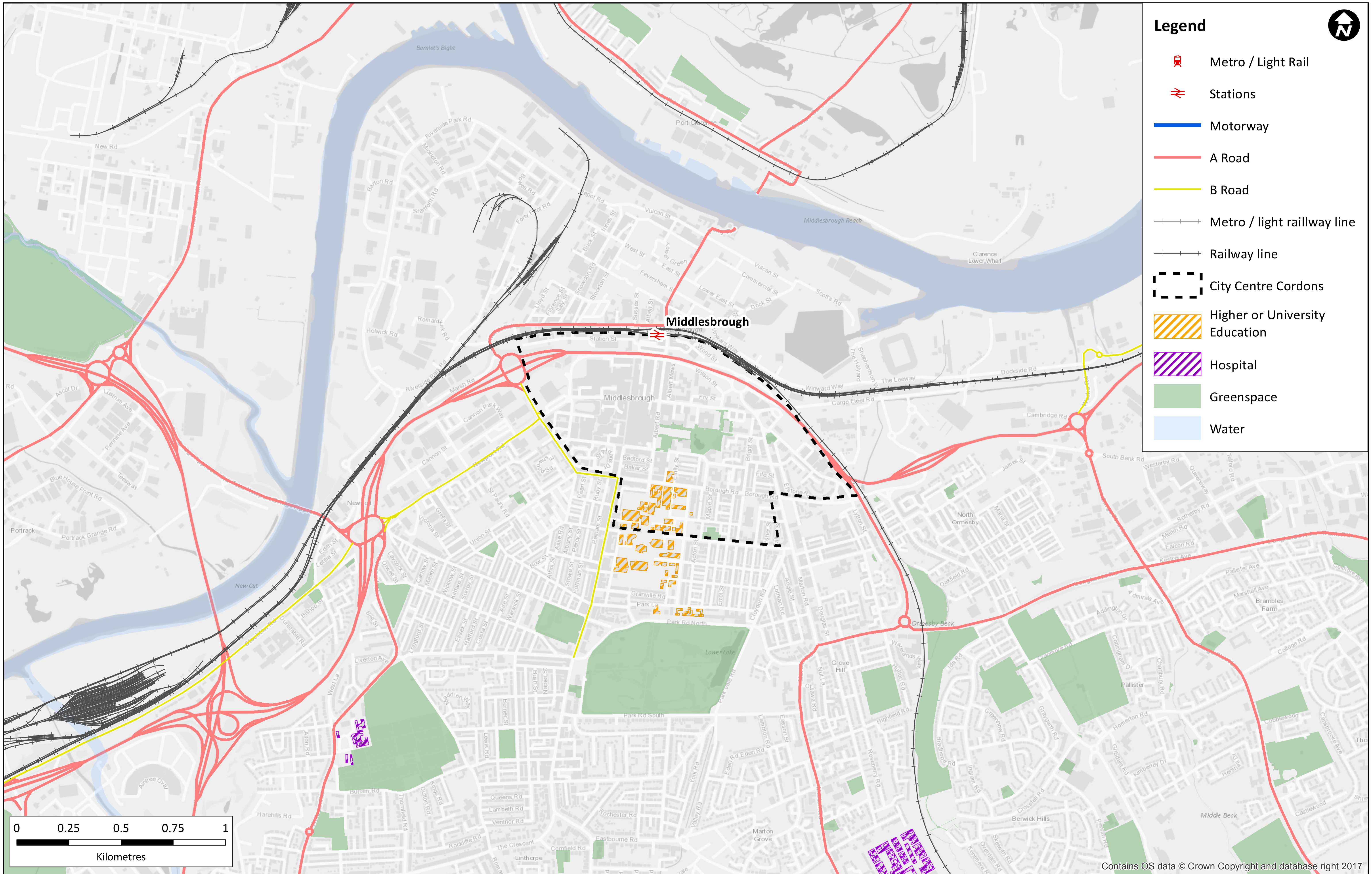

National Infrastructure Commission Capacity Review

Middlesbrough

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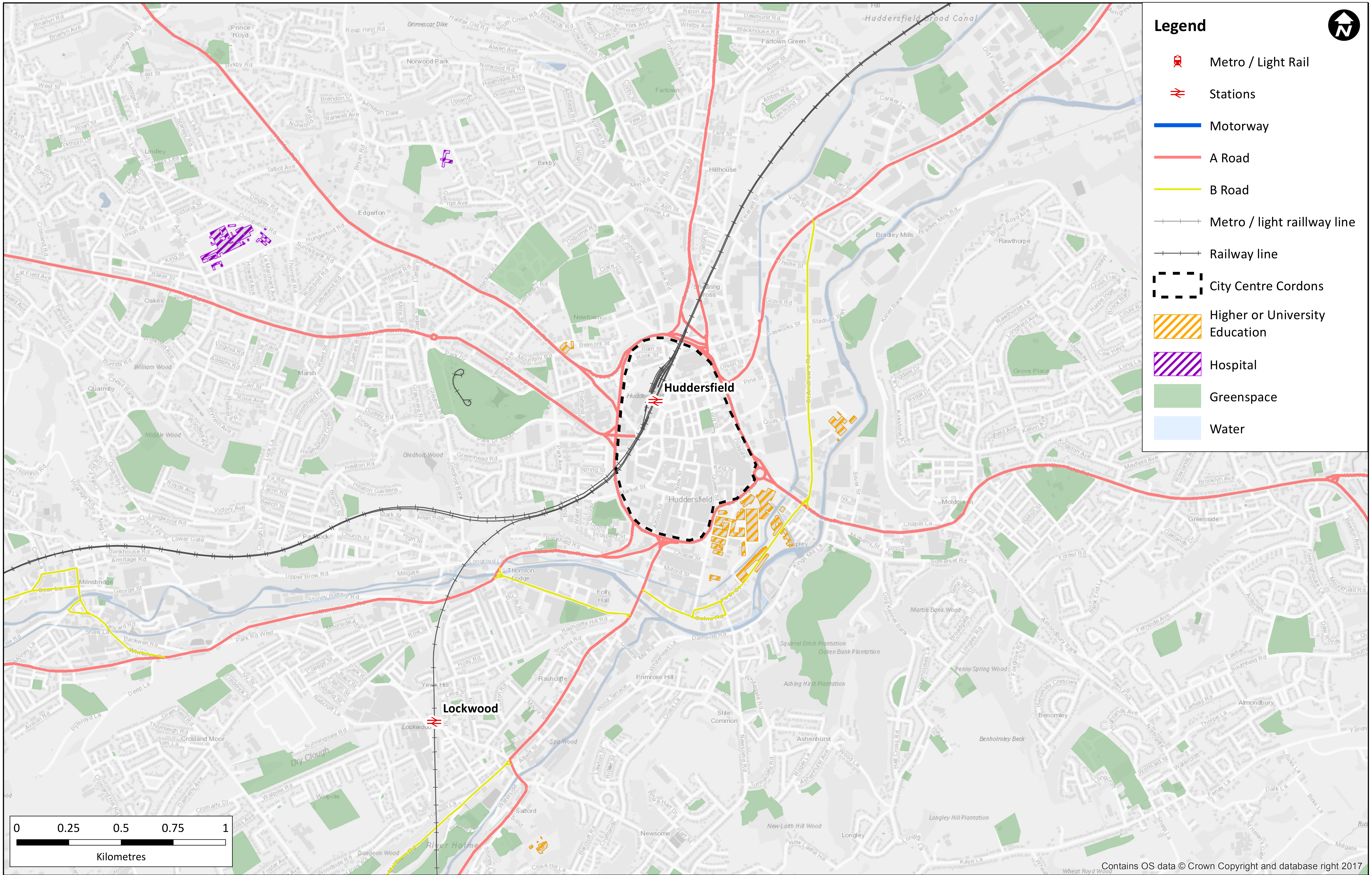

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Huddersfield

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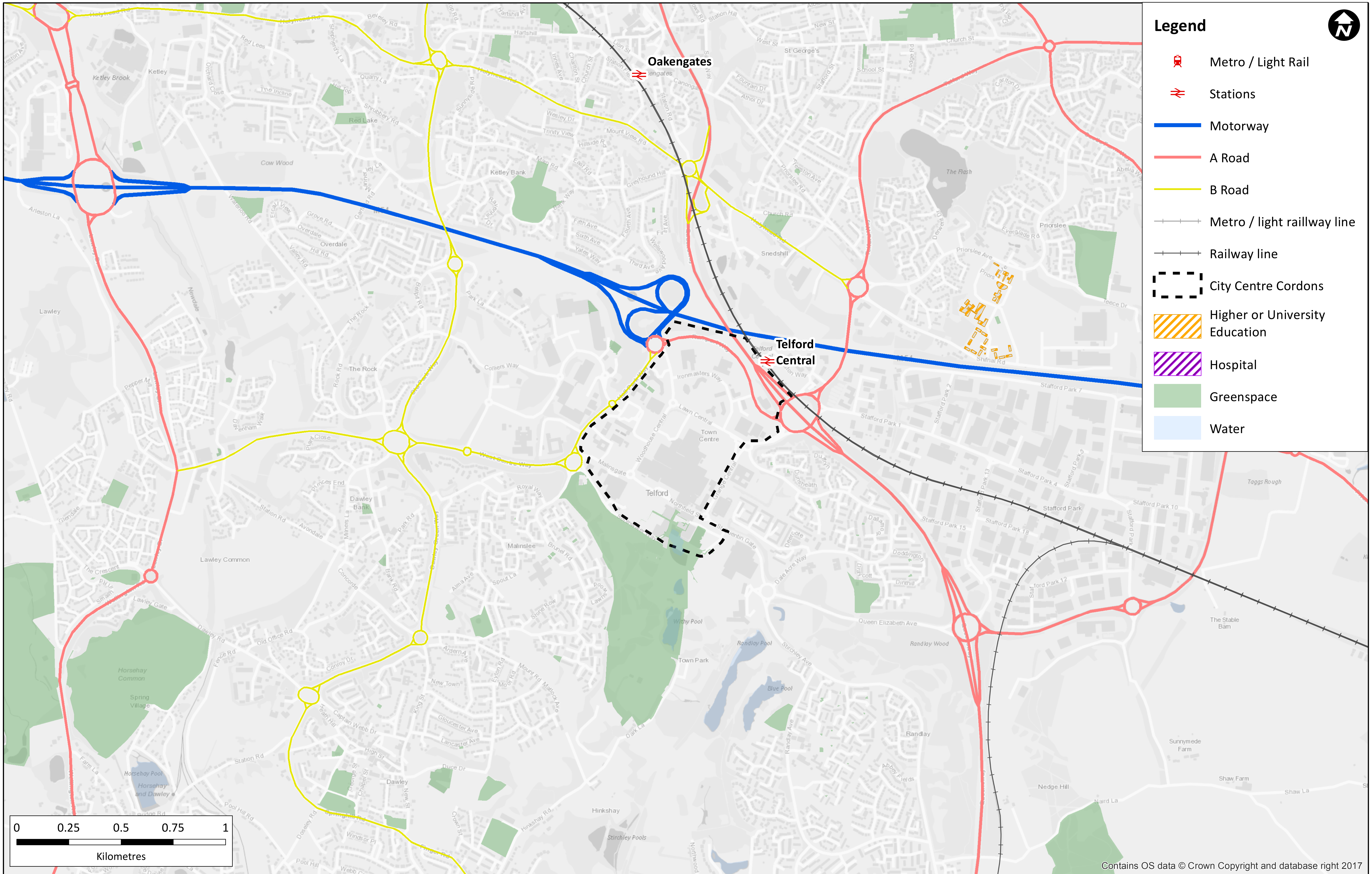

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Telford

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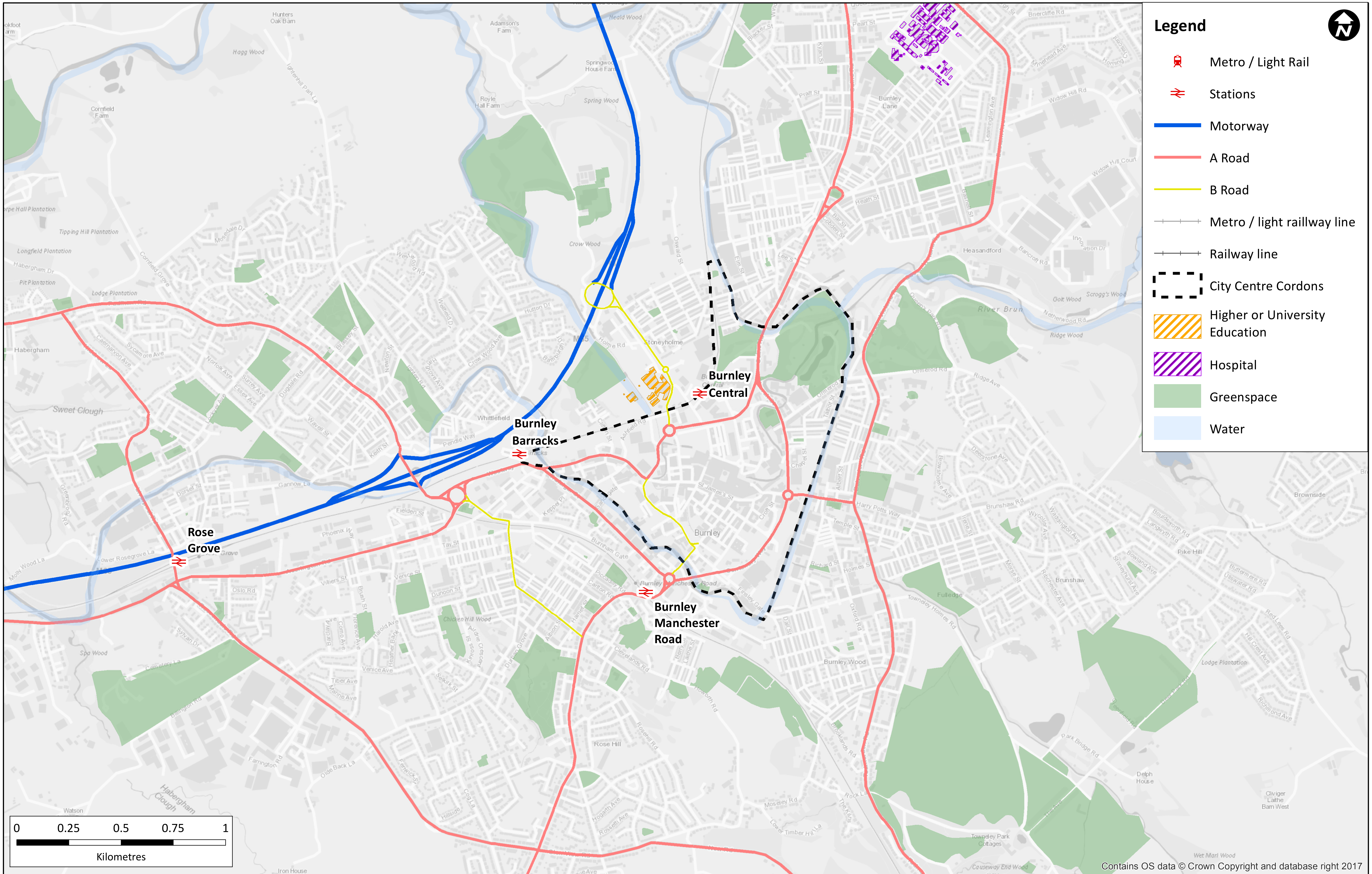

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Burnley

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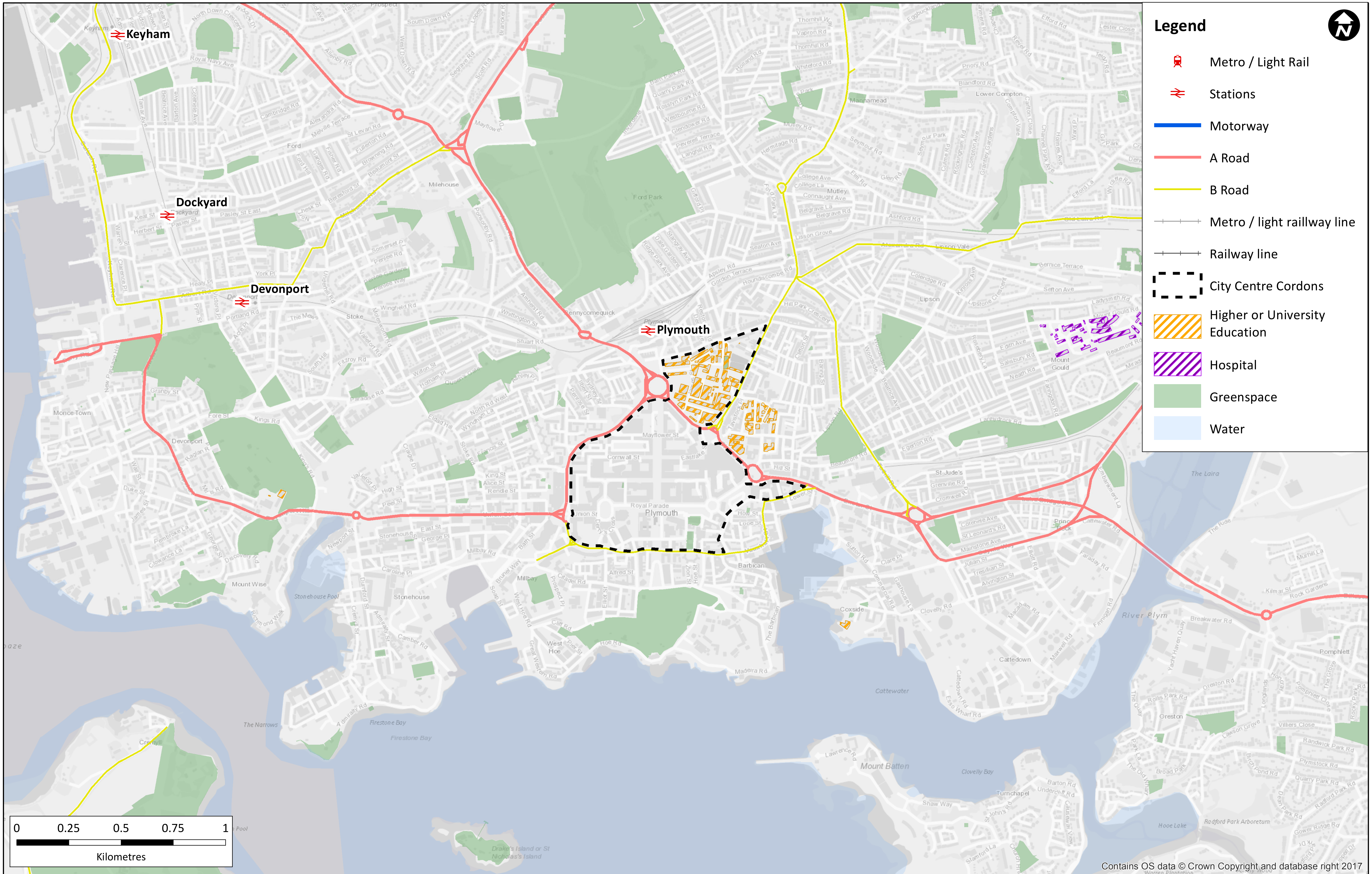

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Plymouth

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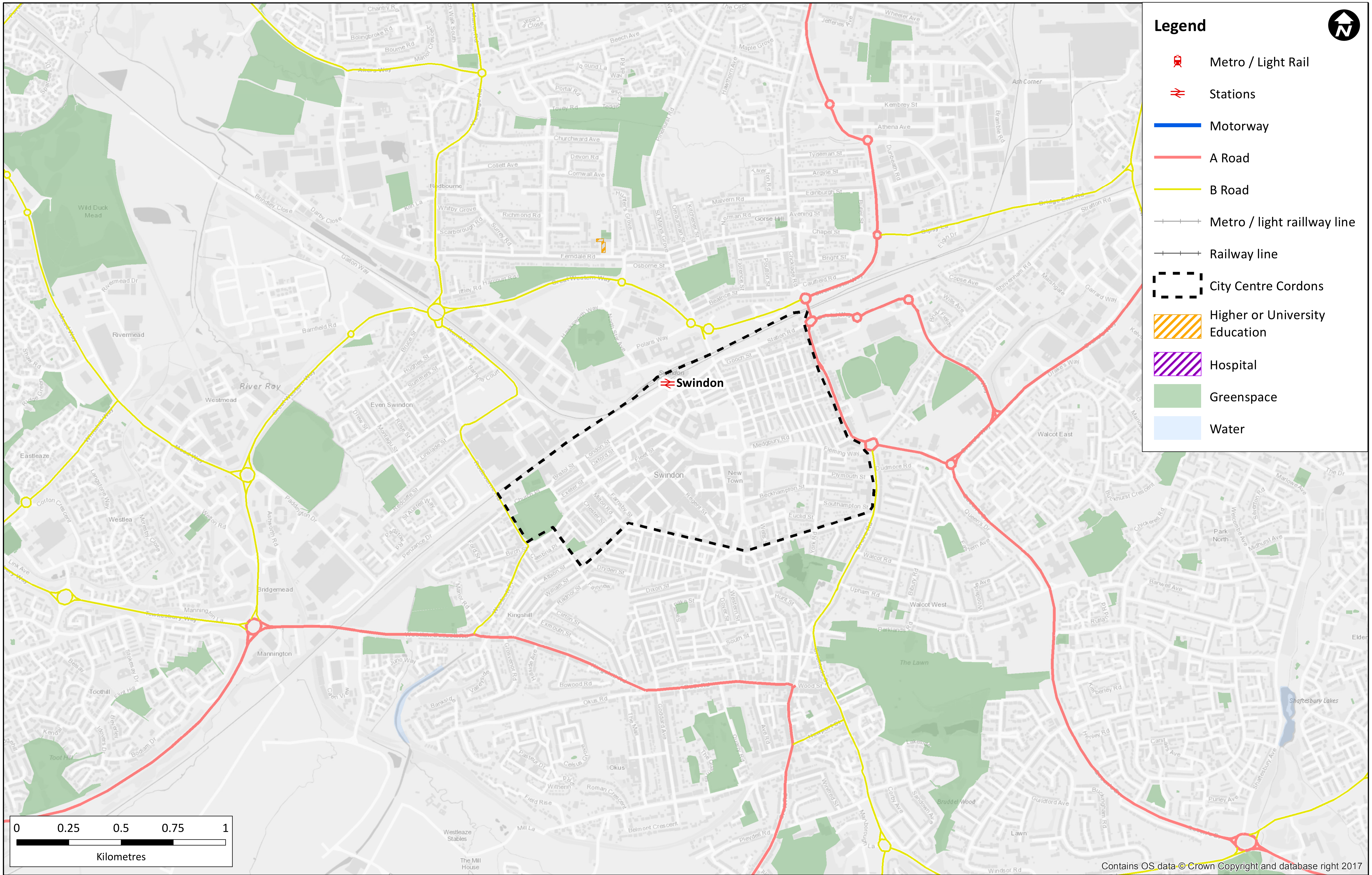

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Swindon

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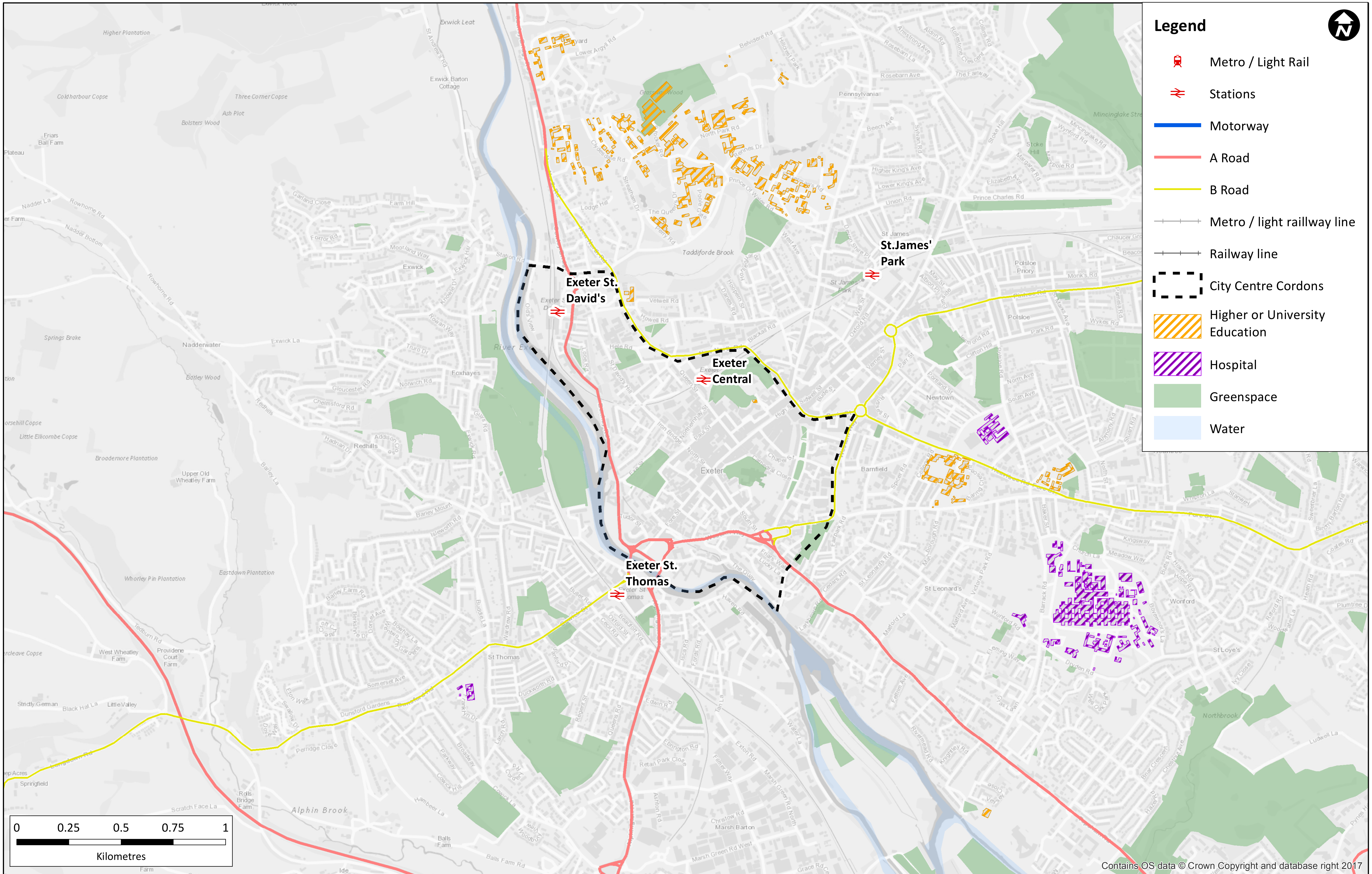

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Exeter

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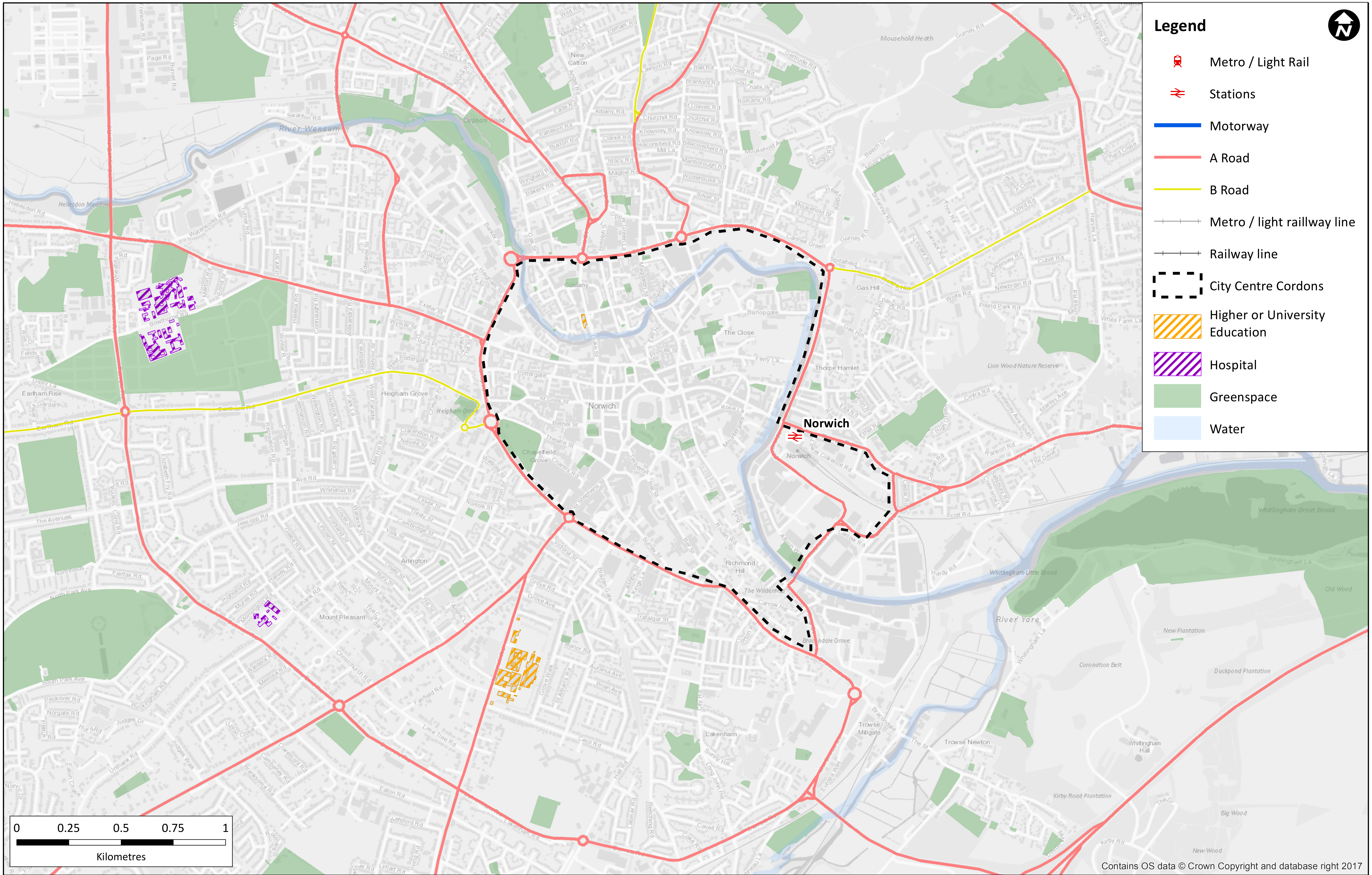

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Norwich

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Control Information

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V3.0 Final Report for issue	13-03-2023