CREATING A BETTER PUBLIC TRANSPORT SYSTEM EVEN WHEN THE ‘C’ IS TAKEN OUT OF ‘CBD’

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ABSTRACT

The earthquake on 22 February 2011, in Christchurch, New Zealand, had a considerable impact on the City’s transport systems. In some areas roading infrastructure was; structurally damaged, covered by debris, or affected by liquefaction and flooding. Limited access to the CBD and eastern areas of the city resulted in business relocation, requiring residents to change their travel patterns. This also focused activity at Key Activity Centres located outside the CBD.

This change in city dynamics required public transport services to be altered immediately, and fundamentally in many cases, as most of the pre earthquake routes originated and terminated at a central city bus exchange, as well as routing through the eastern suburbs.

Working with Environment Canterbury, a series of proposed post earthquake routes were developed, mapped and tested. The accessibility of 133,000 households to Key Activity Centres and new employment hubs was assessed using pre and post earthquake networks. The resulting accessibility maps provided information to decision makers on how best to rationalise Christchurch’s public transport system.

The testing and design of the network has been optimised and the results show that the proposed post earthquake network offers greater accessibility to Key Activity Centres than pre earthquake networks and that there is good but varied accessibility to each of the different employment hubs.

Note: The figures shown within this report have been produced in colour.

INTRODUCTION

Background

This paper explores the development of a new public transport planning system for Christchurch, New Zealand. It is Environment Canterbury's (ECan) responsibility to plan and administer public transport services within the region and it does this using the powers of the Public Transport Management Act 2008 (PTM Act)(Environment Canterbury 2011).

As part of ECan's planning role, the PTM Act requires the adoption of a new Regional Public Transport Plan (RPTP) in 2012. The RPTP sets out how ECan intends to give effect to the public transport service components of the Regional Land Transport Strategy, and to contribute to the purpose of the PTM Act in an efficient and effective manner.

A Network Plan was to be developed to be included in the new RPTP. This plan would identify key public transport corridors and routes for the future which would guide the service planning and help the three local councils, i.e. Christchurch City, Selwyn District and Waimakariri District. The RPTP would then assist these councils to plan the infrastructure needed to support the future public transport network. A greater Christchurch accessibility model was used to test and measure the performance of various proposed networks and inform development of the plan.

In February 2011 Christchurch was struck by a magnitude 6.3 earthquake. This changed the outcomes required for the RPTP and, rather than the formulation of a long term Network Plan, a short term network reassessment was needed. This was because the ability to supply the pre earthquake public transport network was immediately lost due to the closure of the CBD, and the damage to the eastern areas of the city. Additionally, given residents were forced to modify their destinations, the demand for public transport also changed.

Aim and Objectives

Following the Christchurch earthquake of February 2011, the objectives were modified from planning a longer term network, to planning, testing and optimising a post earthquake network. The aim of the project was then, to improve the accessibility by public transport to Key Activity Centres and explore the public transport accessibility to 8 new employment hubs which formed as a result of business relocating from the CBD. This included an evaluation of both the pre earthquake public transport network and a proposed post earthquake public transport network.

Data

The data used for the analysis includes:

- Pre earthquake public transport network
- Proposed post earthquake public transport network
- 133,404 household address points from the urban areas of Burnham, Christchurch, Kaiapoi, Lincoln, Lyttleton, Prebbleton, Rangiora, Rolleston, Templeton, Waikuku Beach, and Woodend, as shown in **Figure 1**.
- 15 Key Activity Centres located in the suburbs of Barrington, Belfast, Central City, Linwood, Halswell, Hornby, Kaiapoi, Lincoln, New Brighton, Papanui, Shirley, Pegasus, Rangiora, Riccarton, and Rolleston.

- 8 employment hubs located on Blenheim Road, Cavendish Road, Colombo Street (Sydenham), Leslie Hills Drive, Lincoln Road, Main South Road, Nazareth Avenue and Orchard Road (Airport).

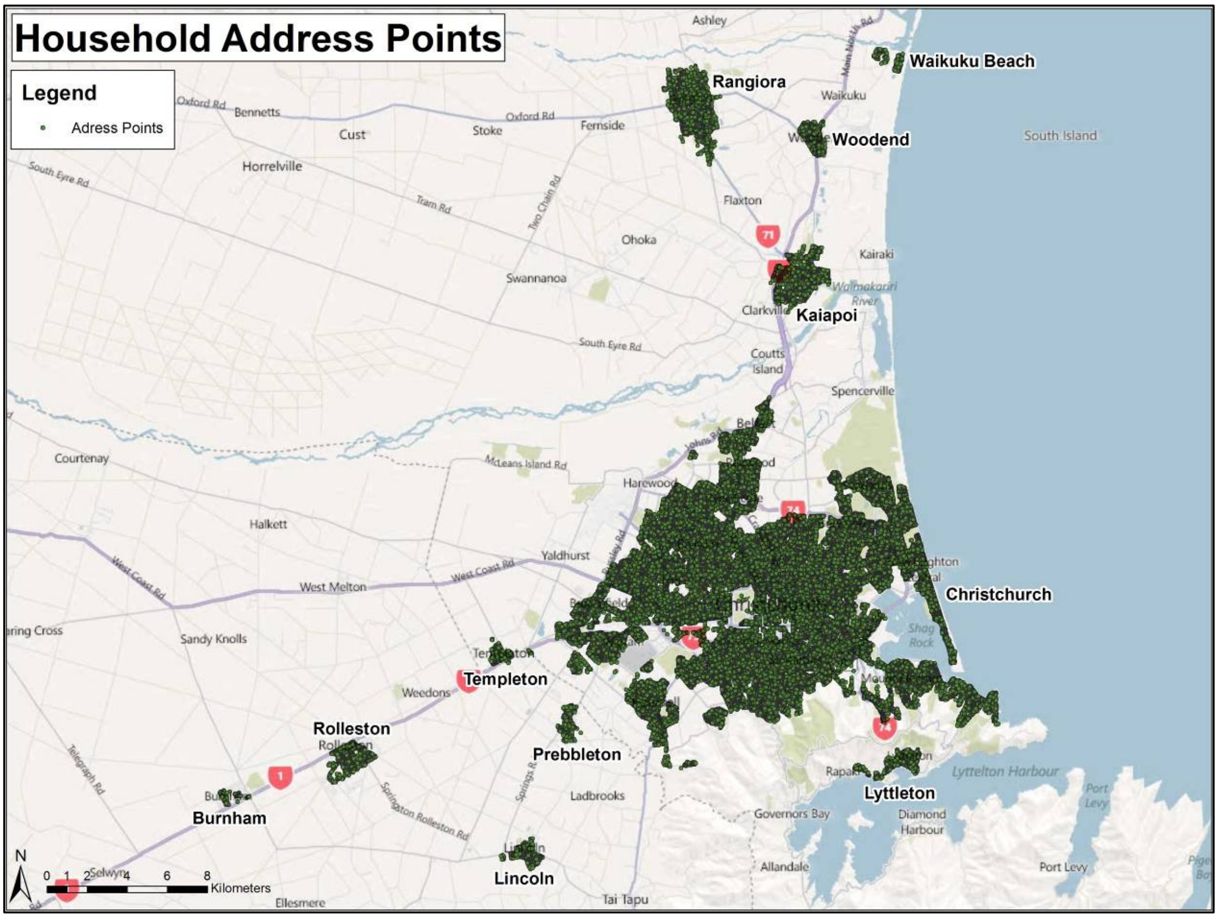

Figure 1. Household address points used in analysis

ACCESSIBILITY MODELLING

Defining Accessibility

Abley (2010) defines accessibility as the ease with which activities, either economic or social, can be reached or accessed by people. Therefore, accessibility assessment is the measurement of how easy it is for an individual to participate in desired activities, based on a set of measurable factors, including mode and destination choice.

Accessibility includes three components: ‘Access’, ‘Opportunity’ and ‘Mobility’. These are described as:

- ‘Access’ represents the ability to use the transportation network. For example a bus with a low floor enables mobility impaired people ease of boarding and access to the public transport network. Similarly being licensed to drive and having access to a vehicle enables people to use the road network.
- ‘Opportunity’ represents the availability of a land use activity or service. For example the presence of a supermarket provides an opportunity for shopping, and a school or college provides opportunity for education.

- 'Mobility' represents the quality of moving through the various transportation networks. For example congestion on a highway often represents the level of mobility for vehicles. The amount of delay when crossing the street often represents the level of mobility for pedestrians.

A Comprehensive Approach

Accessibility is concerned with both the land use and the transport system, and provides an integrated way of measuring changes in either system. The use of an accessibility model, not only provides a more realistic representation of the transportation world (including those that may be transport disadvantaged); but also presents a better measure when considering the long term sustainability of the transportation network. This is because, unlike traditional transportation modelling that typically only models mobility using one or maybe two modes of transport (such as motorised vehicles and public transport), accessibility modelling can evaluate all modes. This includes the traditional modes of transport as well as more sustainable modes of transport such as public transport, walking and cycling.

Accessibility modelling is different to traditional transport modelling because accessibility modelling measures potential rather than actual outcomes. Accessibility modelling can be thought of as measuring the extent to which people 'could' travel, whereas traditional transport modelling can be thought of as 'would' travel. Both styles of modelling are useful, although their purposes are different.

Traditional Transport Modelling

Traditional transport modelling is similar to accessibility modelling in that they both consider the interaction of land use and transport networks. However, traditional transport modelling couples transport supply with the demand for travel and measures mobility, considering how many people or households 'would' choose a particular motorised transport mode.

Consequently these types of models can often result in supply solutions such as adding capacity to roads to enable more efficient travel. However, the analysis of what people can reach or 'would' do does not recognise other travel options that may be only slightly less economically efficient, or are currently not provided, so they are not utilised. Additionally, only measuring what people 'would' reach does not take account of how many people 'can not' travel and those that are transport disadvantaged.

The Accessibility Model

Accessibility modelling is a land use and transport network supply model that acknowledges various modal opportunities and measures what people 'could' do. Accessibility modelling evaluates all transport modes, including traditional modes of transport such as private vehicles, as well as more sustainable modes of transport such as public transport, walking and cycling.

Accessibility modelling is also able to include the various interchanges between these modes such as walk → public transport → walk, car → car park → walk, cycle → public transport → cycle → walk, and so on. This provides a realistic representation of the transportation world because it considers the separation of origins and destinations and provides a means to measure the long term sustainability of the transportation network. This includes not only what people 'could' reach, but also what they can't reach and by inference transport 'need'.

This model achieves a different way of looking at how transport is provided. Accessibility modelling is a newer tool for transport planning, even though providing opportunity is a common transport planning technique. Unfortunately over decades of refinement providing opportunity has morphed into extending 'vehicle reach' rather than 'reach by all people'.

Accessibility modelling untangles and clearly presents the different levels for the ability to reach. The difference between household and destination reach for all transport modes is shown, and in doing so the decision making toolkit is rebalanced. Accessibility modelling helps inform a move away from only considering mobility i.e. vehicle mobility, as the principal measure of a good transport system. It can also help inform how less able members of our community can be better integrated and show if and where gaps exist in providing transport options.

LOSS OF ABILITY TO SUPPLY

Immediately following the February 2011 earthquake, due to the substantial damage that occurred, the CBD was cordoned off, as shown in **Figure 2**. Before the earthquake most buses travelled through the Central City Bus Exchange that was now structurally unsafe and within the cordon, and therefore inaccessible. Eastern areas of the city were also badly affected by the earthquake and its effects.

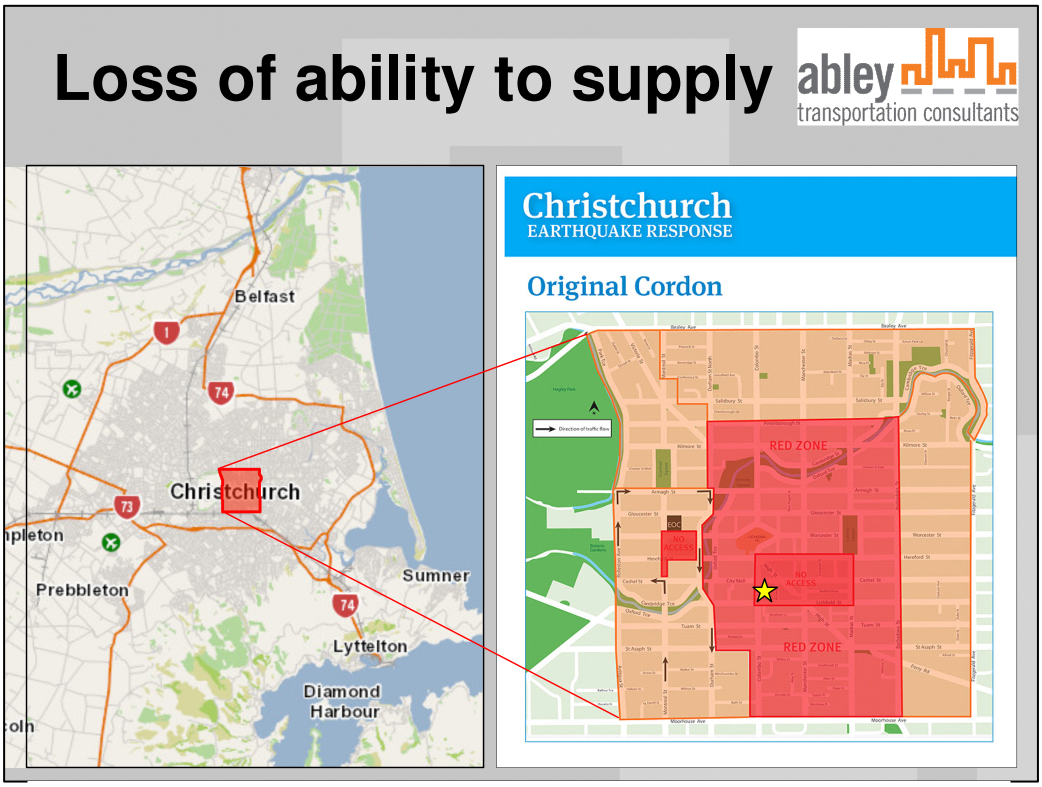

Figure 2. Christchurch CBD cordon. The yellow star shows location of the pre earthquake bus exchange (Christchurch City Council, 2011)

Liquefaction and flooding covered entire neighbourhoods, as shown in **Figure 3**, and structural damage to some roads made them impassable, as shown in **Figure 4**.

Figure 4. Structural damage to River Road, Richmond, Christchurch (Hallett, 2011)

Figure 3. Liquefaction and flooding in a Bexley neighbourhood (Mitchell, 2011)

Using the accessibility model, the performance of the public transport network prior to the earthquake is shown in **Figure 5**. The model includes households (origins), a detailed walking network, traffic flows that are used to calculate pedestrian delays (mobility) and bus stop locations (destinations). The light blue areas show the sections of the road network where houses have access to a bus stop within 250m and the dark blue areas have access within 500m. The black areas do not have access within 500m.

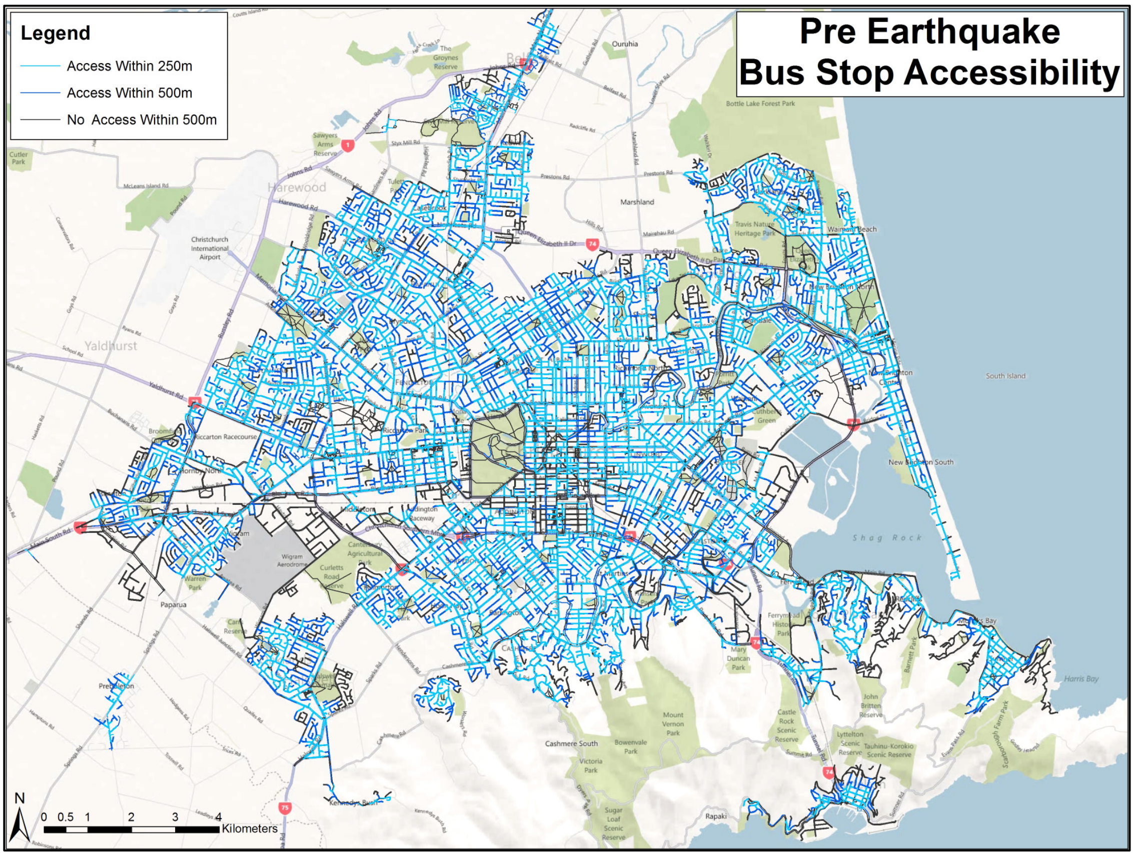

Figure 5. Pre earthquake bus stop accessibility

The results of removing those parts of the network that no longer have services, due to non-trafficable routes post earthquake in the CBD and eastern suburbs, are shown in **Figure 6**. The red areas show the parts of the network that lost access to a serviced bus stop within 500m of a household. The results of this analysis quantified the areas of immediate need following the earthquake.

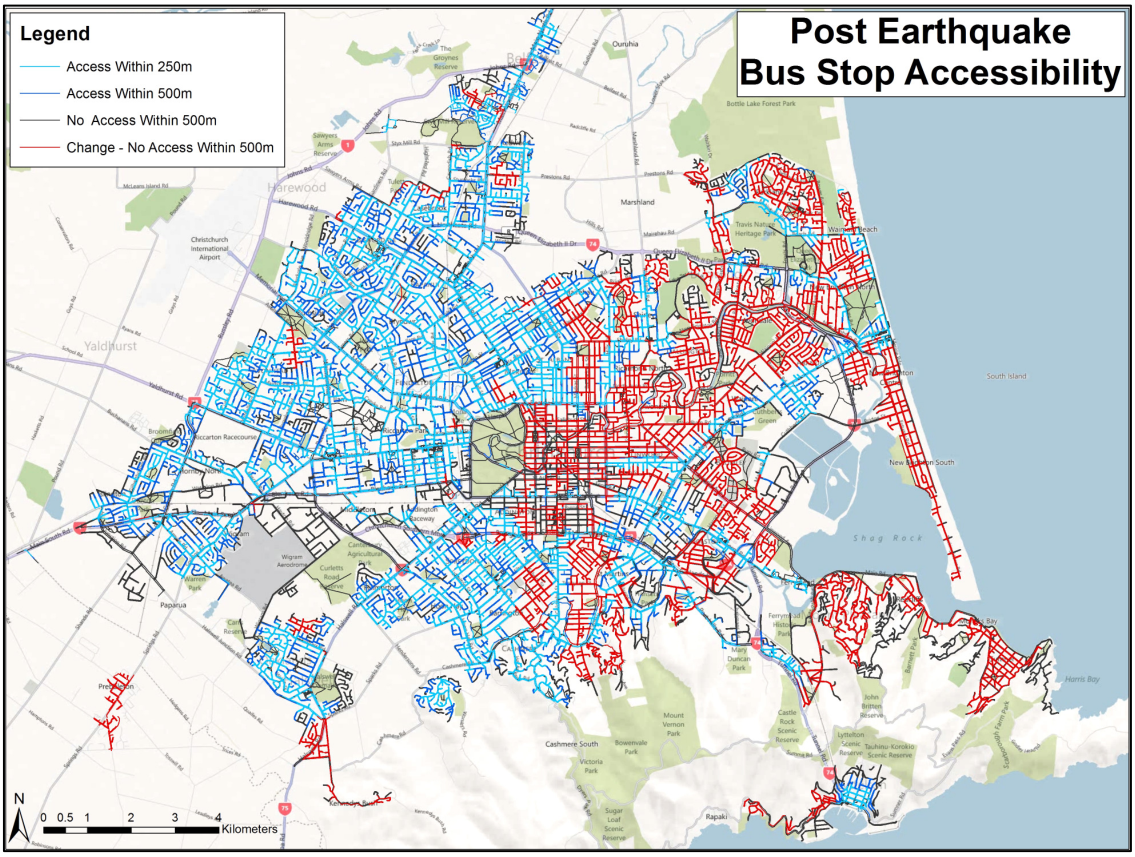

Figure 6. Post earthquake bus stop accessibility

CHANGE IN DEMAND

Access to a bus stop is an important determinant in the supply of the public transport system, but it does not give any regard to where people want to go. The analysis can be improved by including end of journey destinations. After the earthquake, a lot of the demand for the end destination of the CBD changed due to its inaccessibility as CBD tenants transferred to outer suburbs. Some of these locations are shown in **Figure 7**.

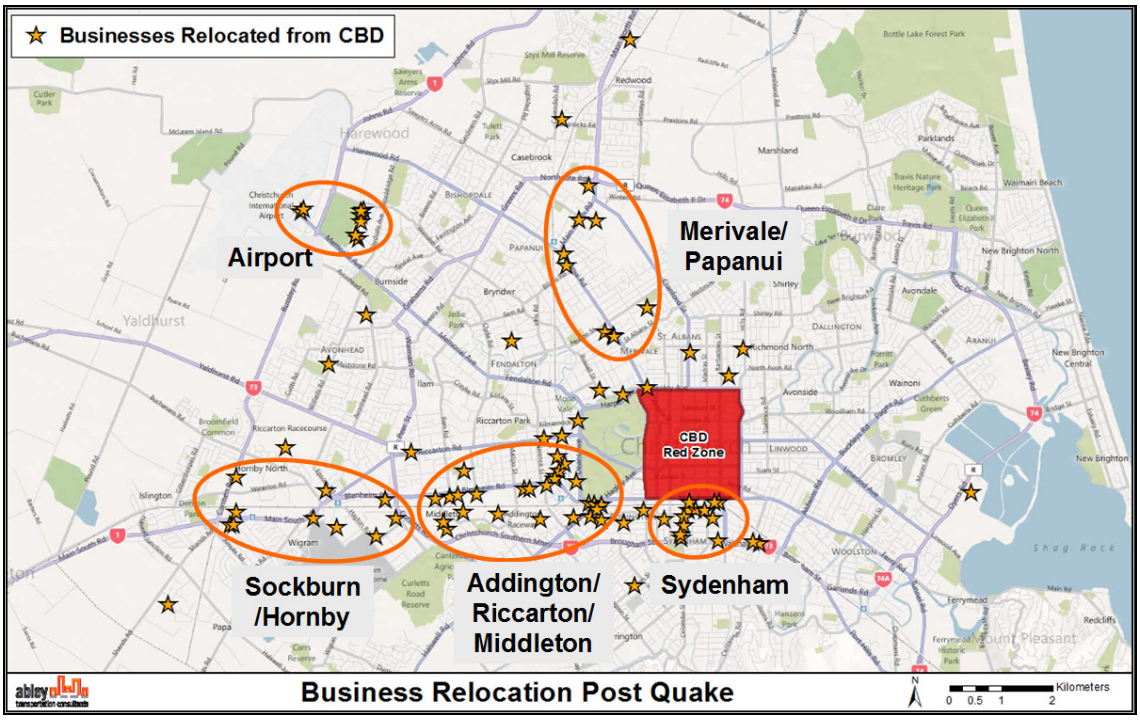

Figure 7. Business relocation from the CBD, post earthquake

A series of proposed post earthquake public transport routes were mapped so decision makers could determine how best to rationalise Christchurch's public transport system. The routes were mapped with an assumption that all eastern areas and the CBD would, within time, be open and functional, and that the buses would be able to route freely within the CBD, as they had pre earthquake.

The proposed routes were determined in consultation with ECan, where they knew of specific needs, and through the accessibility analysis that had been undertaken prior to the earthquake. The earthquake also provided the opportunity for routes which were identified to take effect in the long term, could be brought forward into the short term if they still achieved an improvement in accessibility. This was carried out in light of the different passenger destinations identified in Figure 7.

ACCESSIBILITY ANALYSIS OF KEY ACTIVITY CENTRES

Accessible Public Transport

ECan has defined 'accessible public transport' as being able to travel on public transport from a house to two or more Key Activity Centres (KACs) within 30 minutes and where the bus stop is within 500m.

Key Activity Centre (KAC)

A Key Activity Centre (KAC) is a location in a planned community that includes shopping, commercial, employment and household locations. A KAC is a designation that it is a significant centre that provides for a neighbourhood to be self sufficient and provide for its own needs. Consequently, everywhere in Christchurch should have accessibility to at least one KAC and accessibility to more than one KAC provides consumer choice. A KAC is formally defined in the Canterbury Regional Policy Statement.

KAC Accessibility Analysis

In this instance, accessibility is measured as a person being able to catch a bus from no further than 500m away from their household and travel to a KAC within half an hour. This means the journey includes the walk from the household (origin) to the bus stop, the wait for the bus, travel on the bus to the bus stop closest to the KAC, then the walk to the KAC (destination).

The accessibility model includes for all these trip legs that combine to form a complete journey. The accessibility model is particularly powerful because it accurately reflects the real world, including bus transfers if they were determined to be within the journey time threshold.

Results

The accessibility of Christchurch using the above measure, pre earthquake, is shown in **Figure 8**. The pink stars are KACs and the blue areas are households that have access to at least 2 KACs within 30 minutes, while the green areas are households that have access to one, and the red areas are households that have access to none.

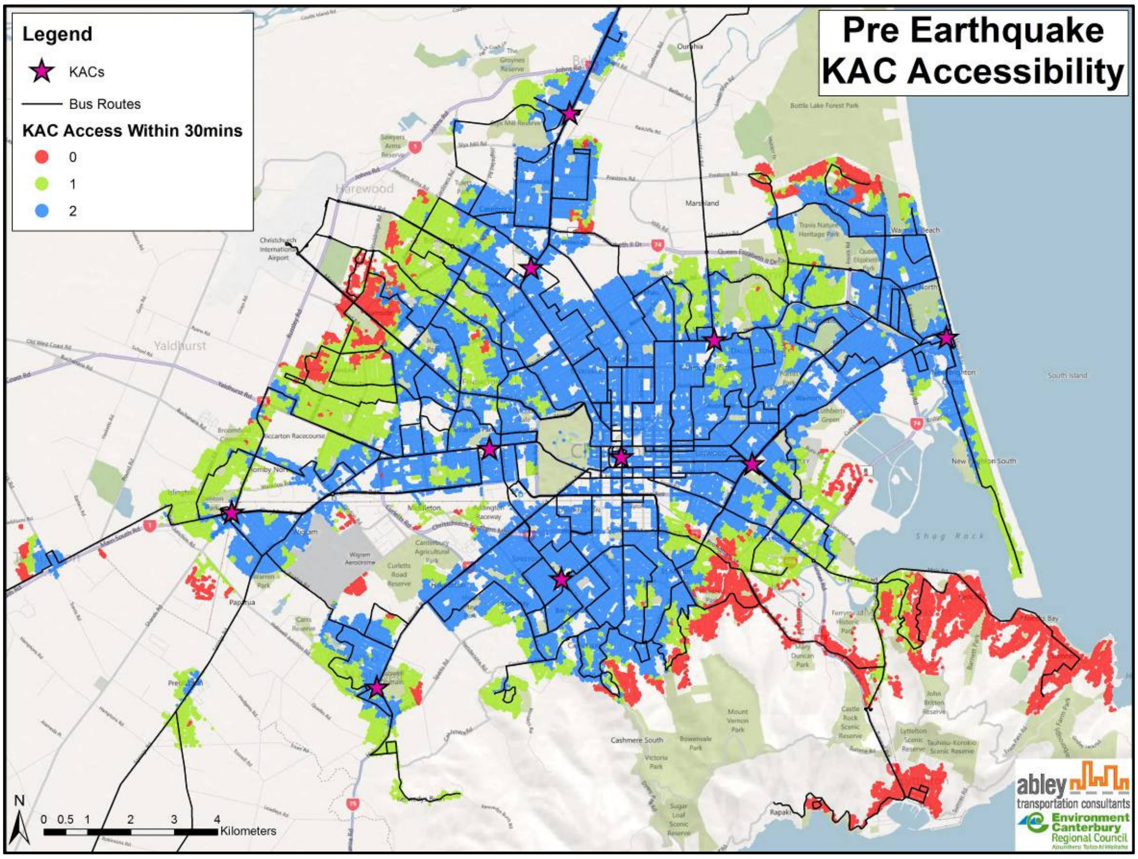

Figure 8. Pre earthquake KAC accessibility

Using the same colour graduations but utilising a new public transport network provides the results shown in **Figure 9**.

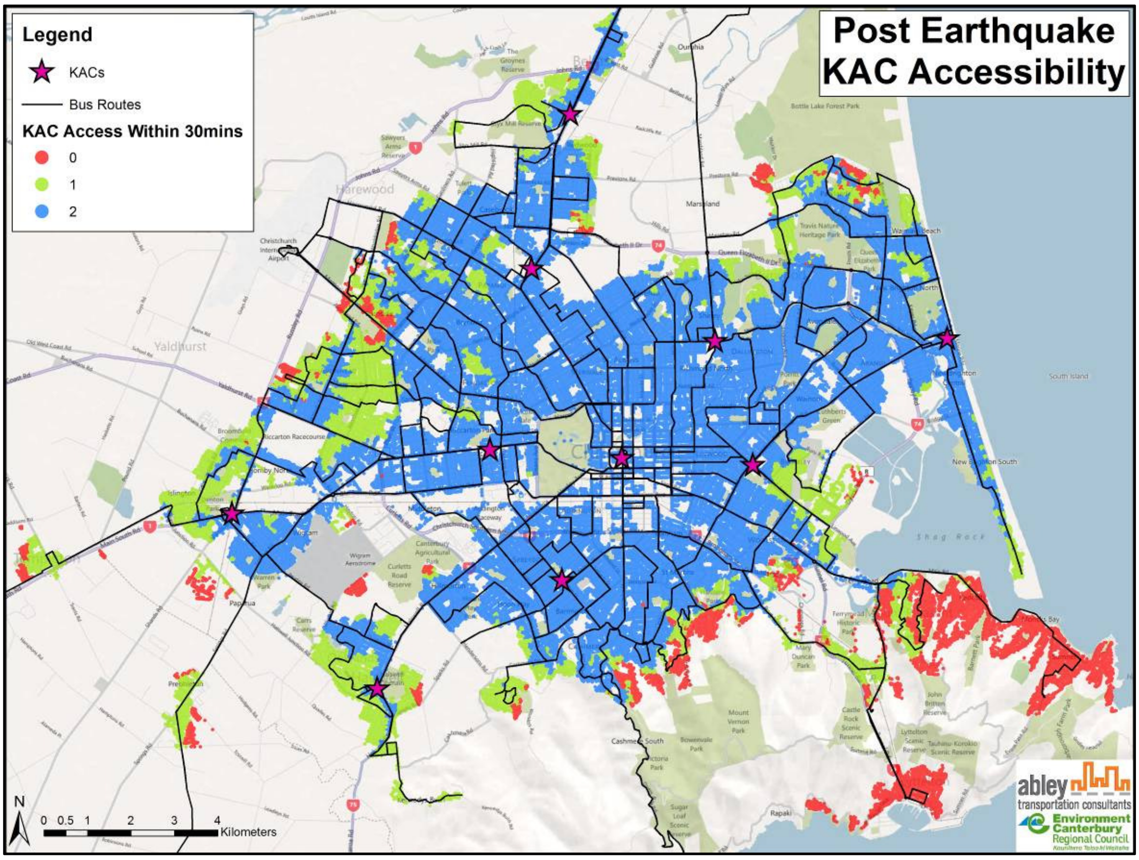

Figure 9. Post earthquake KAC accessibility

The change in accessibility between Figure 8 and 9 is subtle, but important, and is shown in **Figure 10**. Households that had no change in accessibility to a KAC are shown in the grey areas. Households that had an increase in accessibility are shown in blue. The light blue areas represent households that can access 1 additional KAC and the dark blue areas represent households that are able to access 2 additional KACs. Households that had a decrease in accessibility are shown in red and orange. The orange areas represent households that have lost access to 1 KAC and the red areas represent households that have lost access to 2 KACs.

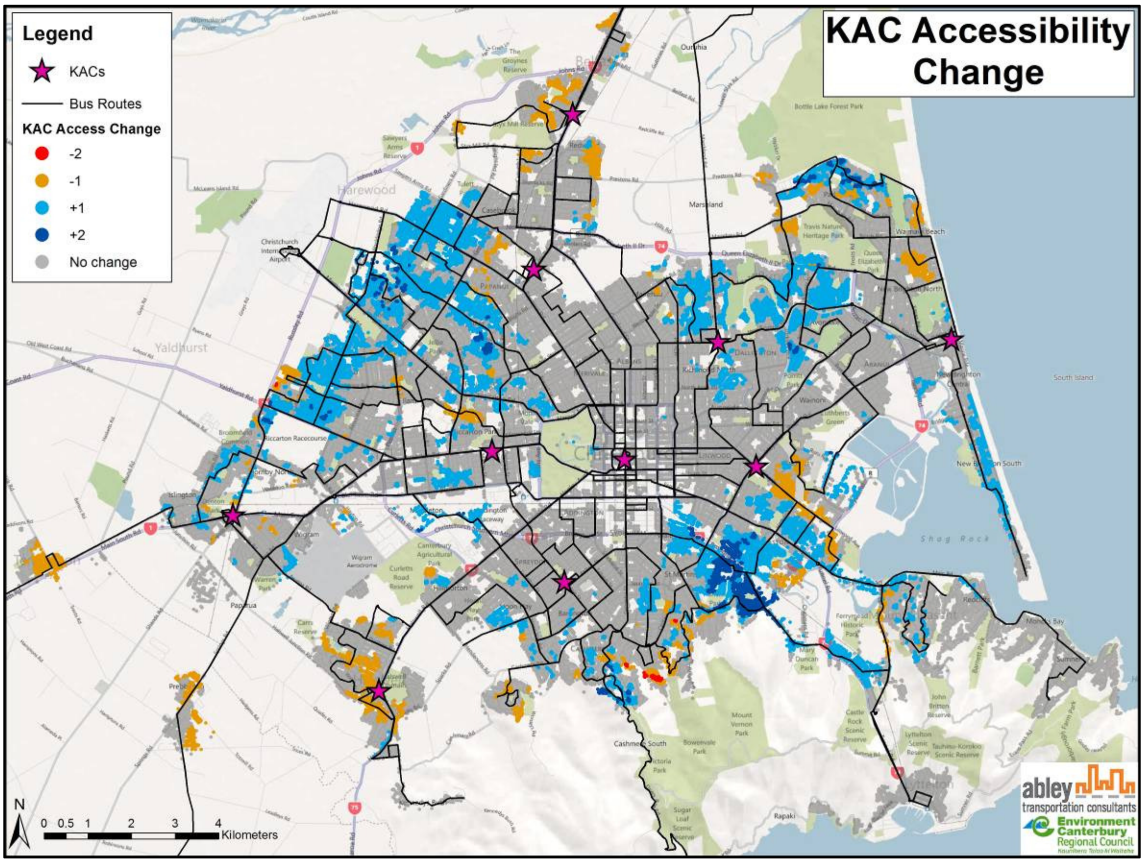

Figure 10. Change in KAC accessibility with the pre and post earthquake networks

Overall, 15% of households show an increase in accessibility and less than 6% of households experienced an overall decrease in accessibility. The less than 1% of households that lose access to 2 KACs are barely noticeable.

Discussion

The difference between the pre earthquake and post earthquake public transport networks is that the public transport system has been better designed and optimised using the accessibility model to improve the quality of service. The modelling increased overall accessibility by 9% by simply reviewing the existing public transport services. This resulted in improved accessibility to approximately 20,000 households.

One area in which this improvement is obvious is to the North West of the city. Prior to February, many of these households had no access to a KAC within half an hour, and only a few had access to one (see Figure 8). One of the proposals that was tested, and has since been implemented, is a new route running in a northwest arc between Northlands Mall and Hornby via the airport. This new route is shown in **Figure 11** and is named the 'Comet'. It generally provides at least a 1 KAC improvement for households adjacent the route.

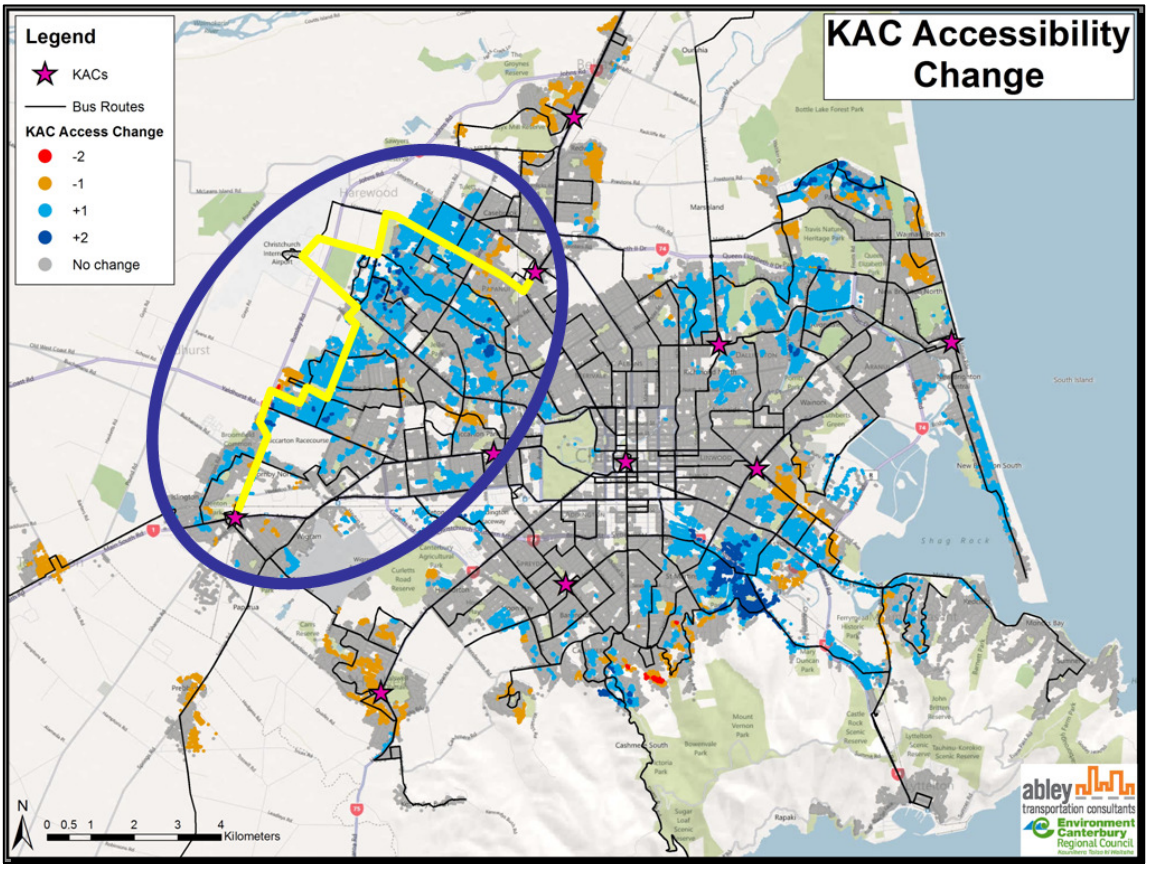

Figure 11. Need for new bus route identified

ACCESSIBILITY ANALYSIS OF EMPLOYMENT HUBS

The accessibility model was also used to test accessibility to the major employment hubs identified in Figure 7. Two examples of the destination based analysis are explored in this paper, these are the KACs at the Airport and Sydenham. The airport is on the northwest edge of Christchurch, while Sydenham is situated in a central location. Also included is an origin based accessibility analysis to all the employment hubs.

Example 1: Destination (Airport) - Results

Household accessibility to the airport is shown in **Figure 12**. The dark blue areas of the network are able to reach the airport within 10 minutes, the light blue within 20 and the orange within 30 minutes. A significant part of the city is not accessible within 30 minutes, shown in red, and some parts of the city cannot access the airport within 60 minutes, shown in grey.

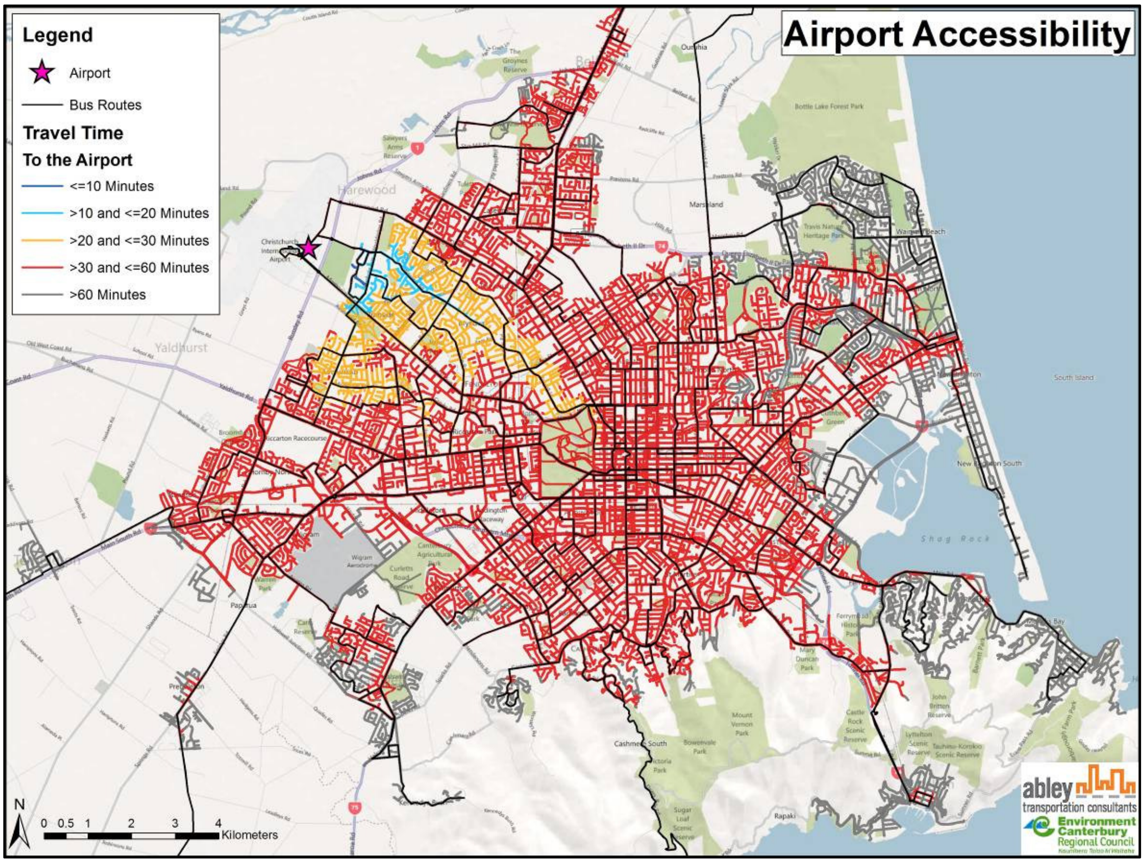

Figure 12. Employment hub accessibility – Airport (destination)

Example 2: Destination (Sydenham) - Results

The accessibility to the employment hub of Sydenham is shown in **Figure 13**. Again, the dark blue areas of the network are able to reach the airport within 10 minutes, the light blue within 20 and the orange within 30 minutes. The areas of the city to which Sydenham is not accessible within 30 minutes are shown in red, and within 60 minutes are shown in grey. It is interesting to note that due to the more central location of Sydenham, there are very few grey households that are not within 30 minutes public transport journey time to this employment hub.

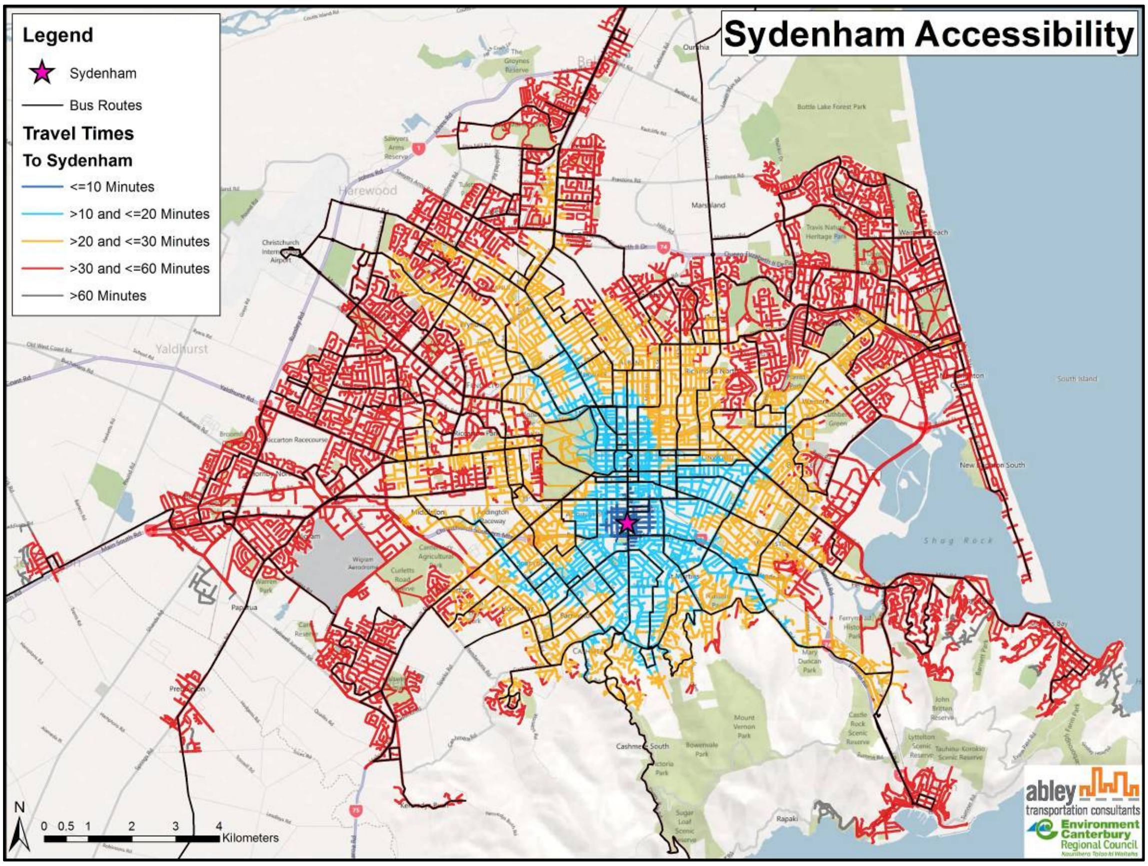

Figure 13. Employment hub accessibility – Sydenham (destination)

Discussion

This style of analysis is slightly different to the KAC analysis. This is because the KAC analysis was origin (household) based; the style of analysis shown in Figures 12 and 13 are destination (employment hub) based. A destination based accessibility analysis is a much simpler analysis and, overall, provides less understanding of accessibility than an origin based analysis. Even so, it does provide some useful comparisons.

As mentioned, origin based accessibility assessments are significantly more enlightening than destination based assessments. As an example, the two destination based assessments shown earlier have been combined with other destination based employment hub assessments and converted into an origin based assessment. The origin (household) based accessibility assessment to various synthesised destinations (employment hubs) from Figure 7 is shown in **Figure 14**. This figure shows how many employment hubs households can access within half an hour. The range is from none, in grey, and mostly to the east of Christchurch, to 7 in purple, which is focused around the Riccarton area to the west of Hagley Park.

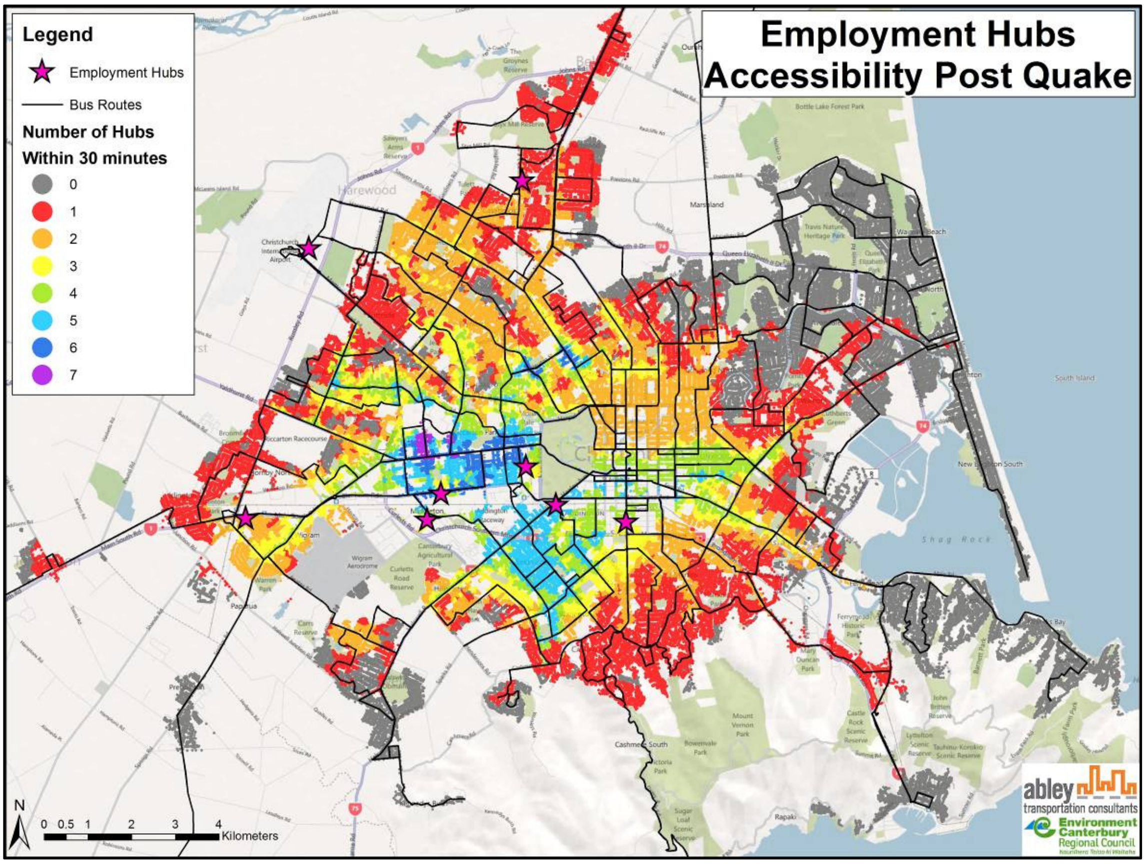

Figure 14. Employment hub accessibility (origin)

Overall the proposed network is highly variable with respect to access to employment hubs and reflects a city that has quickly adapted to tenant locations rather than integrated land use planning. Nevertheless, this is a useful real world example of measuring the level of land use and transportation integration.

CONCLUSIONS

Accessibility modelling is a powerful transport planning tool and provides a new way to look at old problems. In this instance, the accessibility analysis was able to help Environment Canterbury quantify areas of good and poor accessibility, and where areas of poor accessibility exist, test and measure interventions to optimise the public transport system.

Overall the model is able to highlight the quality of service provided by the public transport system, not simply that a bus (or bus stop) is provided. This enables land use and public transport planners to locate services in areas that will yield the greatest accessibility benefit, thus allowing for the prioritisation of funding.

Accessibility modelling can be applied to many different situations, from transportation network upgrades to land use planning for essential facilities, such as the accessibility to businesses, schools, medical care, and social and recreational activities. This allows for new areas of understanding for where services are most needed. This can then be coupled with demand forecasts to provide robust economic justification for services.

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