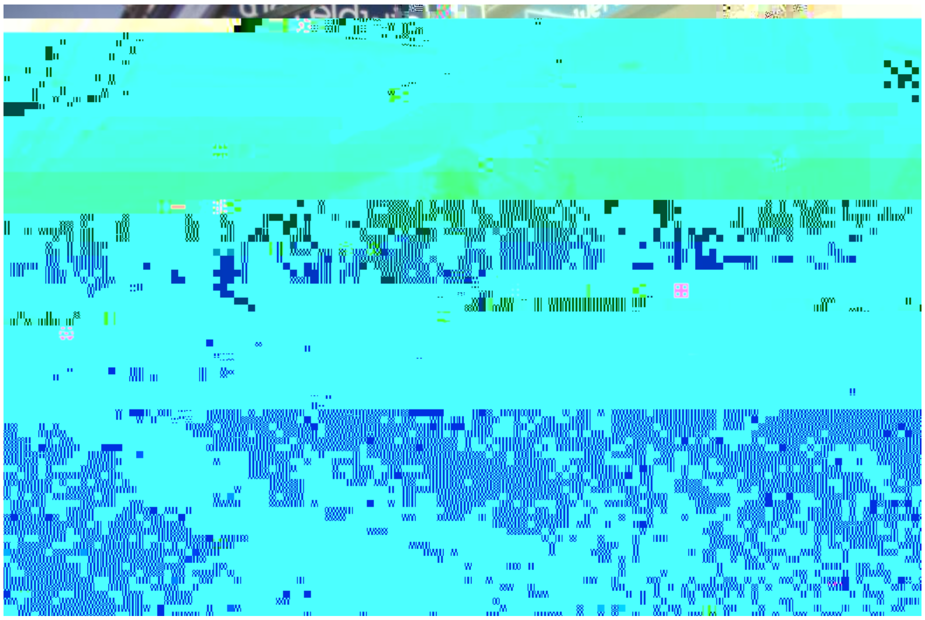

The viability of transitioning food box delivery from motorised transport to electric trikes: a case study of Toha Kai.

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Report prepared for GEOG309 2022

Image sourced from: *Musketier electric trike*

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3 Introduction

Nutritious food is essential for human survival. However, the current food system contributes to a host of global issues. The food system exacerbates existing inequalities, restricting access to healthy and nutritious food in low-income communities

also had to be recalculated. Equation 1 was used in the field calculator and coded in python to calculate updated travel times and convert units for consistency. The one-way restriction was not included in the e-trike network, as cycle lanes tend to go both ways, even on one-way streets. Refer to Appendix A for more detail on the network edge outputs and attribute tables.

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Equation 1. Travel time calculations

Route analysis layers were created using the van and e-trike networks to ascertain the optimized delivery route for both transport mechanisms.

To assess the economic viability of a transition to e-trikes the initial purchase of the e-trike was compared to the cumulative courier van delivery cost. This determined whether the cost of the e-trike would be offset by expenditure saved from not having to pay for courier van delivery. In our research design, wages were not considered due to Toha Kai using volunteer staff. The economic viability was assessed according to a short (1 year), medium (5 years), and long (10 years) timeframe. Through this, the e-trike was able to be deemed viable, moderately viable, and not viable, respective of the time taken to offset the e-trike cost. The results for the three timeframes were summarised in a BCR.

5.2 Ministry of Transport Outcomes Framework

MoT

assess government policy interventions (Ministry of Transport, 2018). Based on values, the three most relevant factors were considered and categorised into costs and benefits: environmental sustainability, resilience and security, and economic prosperwas

6 Results

6.1 Using GIS to optimise delivery

The optimized route for a courier van was calculated to be 68.92km over 140 minutes. In contrast, the optimized e-trike delivery route was found to total 65.88km over 158 minutes.

Comparing these routes, the e-

Figure 5. Qualitative social factors categorised into three outcomes guided by MoT Outcomes Framework (Ministry of Transport, 2018).

6.4.1 Environmental Sustainability

A key driver of transitioning to e-trike delivery is the reduction in emissions profile. This consequently leads to decreases in particulate matter entering air and water bodies, an impact that improves the quality of both and enhances biodiversity (Zhang & Fujimori, 2020). Furthermore, shifting from fossil fuel-intensive forms of transport to an e-trike could reduce road congestion (Weiss et al., 2015).

E-trike implementation has a flow-on effect of increasing demandBT/F912 0 6of5 1 7ead

7 Discussion

7.1 Significance of Results

Research based on the Toha Kai case study week of 45 food boxes suggested the transition from courier vans to e-trikes is an economically, socially, and economically viable option.

The environmental benefit to cost ratio displayed a clear emissions reduction associated with e-trike adoption. Calculating the emissions produced from transporting the e-trike from Germany to New Zealand

Another limitation to this research is that it is based on a case study, therefore, only uses data from Toha Kai to conduct analysis. Considering this a major limitation is the inability to extend our conclusion to other food providers. The e-trike may not be a viable option for other food providers which may have different company values, delivery networks and may not have the final means required in the up-front cost of the e-trike.

7.2.2 Research design

7.2.2.1 Ministry of Transport Outcomes Framework

The MoT Outcomes Framework does not produce a numeric output to quantify the social viability of the e-trike. It is therefore difficult to include the qualitative factors into the CBA, as they cannot be directly compared to the numeric values of the CBA. Instead, the qualitative output is based on a discussion of decided factors. Consequently, the framework may introduce bias into analysis as personal perspective and preference will influence how social factors are discussed. Another limitation is that all five MoT outcomes were not able to be assessed and three outcomes were chosen that were most relevant to Toha Kai. Johnson & Rose (2015) describe how electric bikes provide greater access for older populations and contribute to improved health and wellbeing. Due to the outcomes selected, factors like physical health and wellbeing were not discussed.

7.2.2.2 GIS Analysis

Network analysis assumed the e-trike was constantly travelling at its maximum speed of 25km/h and that the van constantly travelled at the maximum legal speed limit. This is not an accurate representation, as it does not account for stoppages, acceleration, deceleration, or velocity impacts of the physical exertion and fluctuating energy levels of the rider. It also assumes that all one-way streets have bike lanes on both sides of the road. The e-trike network is based solely on the NZ road networks as time constraints meant we were unable to integrate a separate layer of Christchurch cycleways into our route analysis. Consequently, our optimized e-trike route assumes that the cyclist will use cycleways when possible. These limitations, however, did not impact the CBA as they did not influence the distance output obtained.

Another limitation is that the sample data utilised from the case study week may not be a representative distribution of typical weeks. Toha Kai has also been looking to expand their reach and have consequently experienced increased sales

8 Conclusion

Qualitative and quantitative methods were used to assess the viability of transitioning from courier van to e-trike. These methods overwhelmingly found this transition to be an environmentally, economically, and socially viable option for Toha Kai, based on the case study week of 45 food box deliveries. Although we are confident in our results caution and further research should be carried out before extending to this conclusion to other food providers who may have different service areas and company values. Additionally, the reliability of our conclusion may be altered if Toha Kai expanded or if their distribution areas altered significantly.

9 Recommendations

9.1 Toha Kai

Although, route optimisation was conducted, it is encouraged that Toha Kai continues to use a software containing local bike lanes to optimise their travel on the e-trike. This reduces the risk of riders being stranded far from the Toha Kai warehouse.

It is discussed that sharing e-trikes with other businesses can further offset the costs of purchasing the e-trike while also assisting in emissions reductions of the community. However, it is recommended that the maintenance of the product is considered as a part of this investigation.

Further research is recommended with regards to expansion of Toha Kai (see Appendix E). For example, the viability of multiple e-trikes and potential pick-up hubs should be assessed. The latter is particularly relevant if Toha Kai continues to grow outside the range of the e-trike battery. Mass delivery to community

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For small delivery-based companies wanting to reduce their emissions profile who do not have the capacity to transition to e-trikes due to local infrastructure or upfront cost of the e-trike, it is recommended that alternative emission reduction strategies should be considered. Notably, carbon credits, which are a tool that allow people to offset their CO_2 emissions, could be implemented. A single carbon credit is equivalent to 1 tonne of CO_2-e (Toitu Envirocare, 2018) and can be purchased for $81 in NZ (Carbon news, n.d.).

10 Acknowledgements

Over the course of this project, there have been many individuals who assisted in our investigation of the viability of e-75.14 Tm0 g0 G[i)6(gat)ttac1 0 0 1a q01g6-

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12 Appendix A

GIS Network Edge Calculation Outputs

To ensure the e-trike network considered the maximum speed of the e-trike (25km/h), both the estimated speed and the estimated travel time of the e-trike network edges were recalculated. The original nzogps_240215_roads_only layer and thus the recalculated e-trike network edges contain road edge data for the whole of New Zealand. For our purposes, we created a subset of data in and around Christchurch (Figure A1).

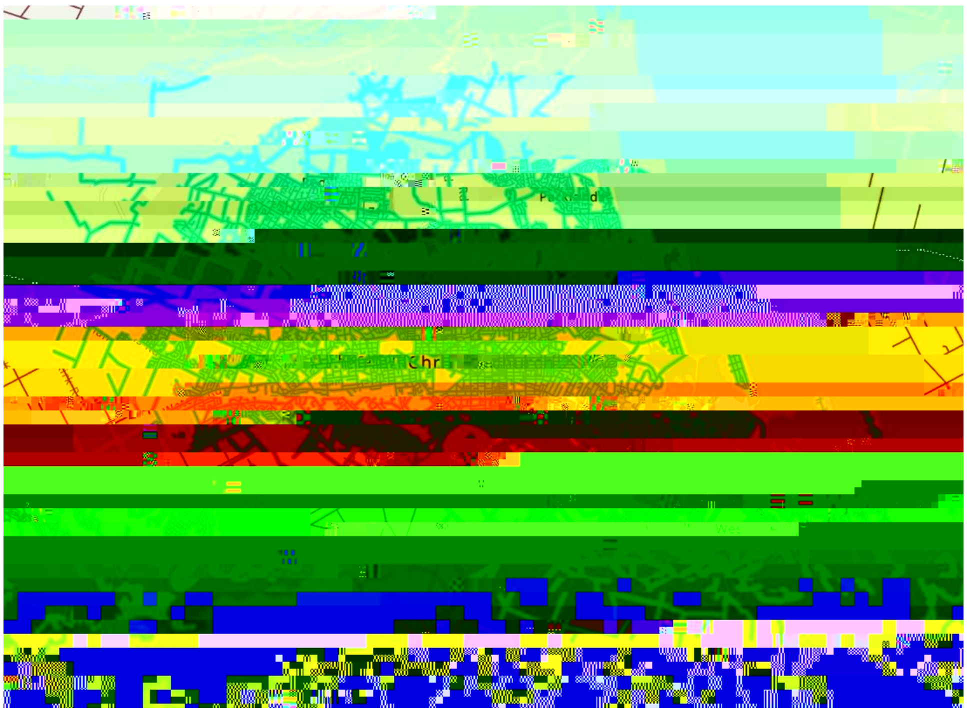
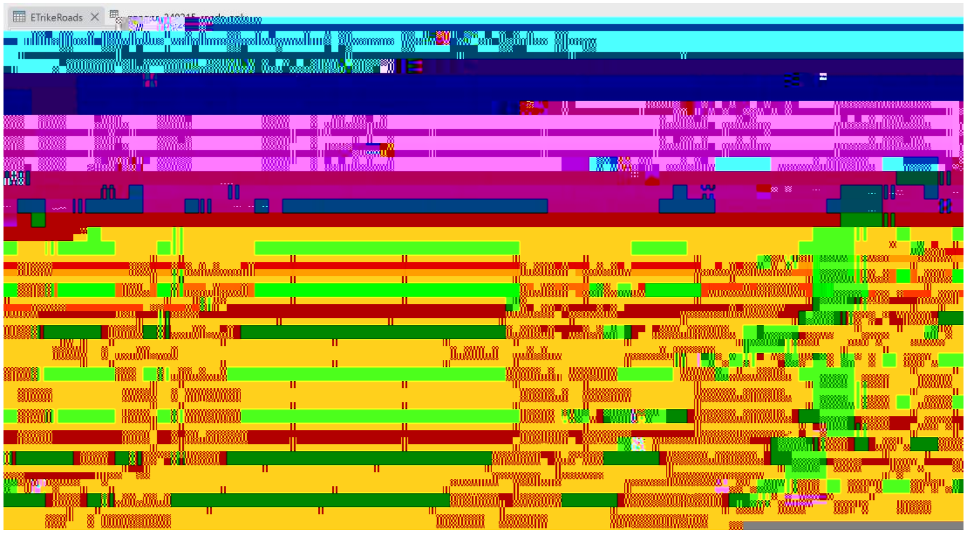


Figure A1. Map of nzogps_240215_roads_only layer (shown in red lines) with the area subset of wider Christchurch selected and shown in blue.

The edges of the delivery van network and the e-trike network can be seen in Table A1 and Table A2 respectively. As these tables contained over 13,500 rows of data, a sample has been selected. As can be seen, the Table A1 estimated_speed and estimated_travel_time values are different from those in Table A2. The Table A2 speed is set to 25km/h and thus tends to also have higher estimated_travel_time values that Table A1.

Table A1. Subset of the nzogps_240215_roads_only attribute table. This data was used to create the

Table A2. Subset of ETrikeRoads attribute table. This data was used as the edge layer in creating the e-trike network.



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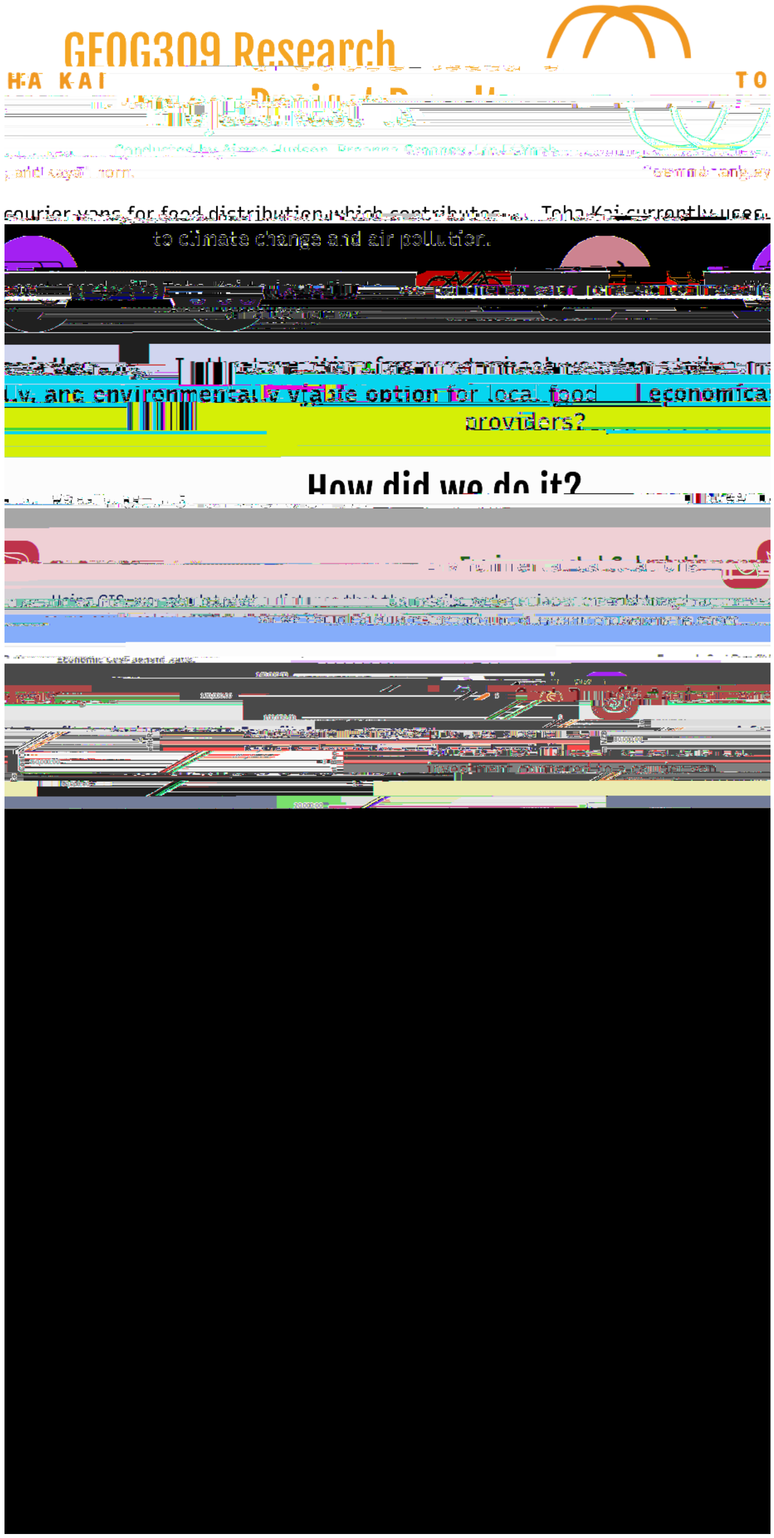
GEOG309 Research
to climate change and air pollution.
providers?
How did we do it?

14 Appendix C

Optimized Route Analysis Details

Figure C1. Output attribute table of optimized e-trike route alongside route map where the e-trike route is represented by the orange line.

Figure C1. Output attribute table of optimized van route alongside route map where the van route is represented by the purple line.

16 Appendix E

Examples of Future Analysis Possibilities

As mentioned in our recommendations, Toha Kai and future research on e-trike viability on larger scales may want to consider options like using multiple e-trike or instating pick-up hubs. Though in-depth analysis into such scenarios was outside of the scope of our research we wanted to give an idea of what such outputs could look like using GIS network analysis techniques of vehicle routing problem analysis, route optimization, and service area analysis.

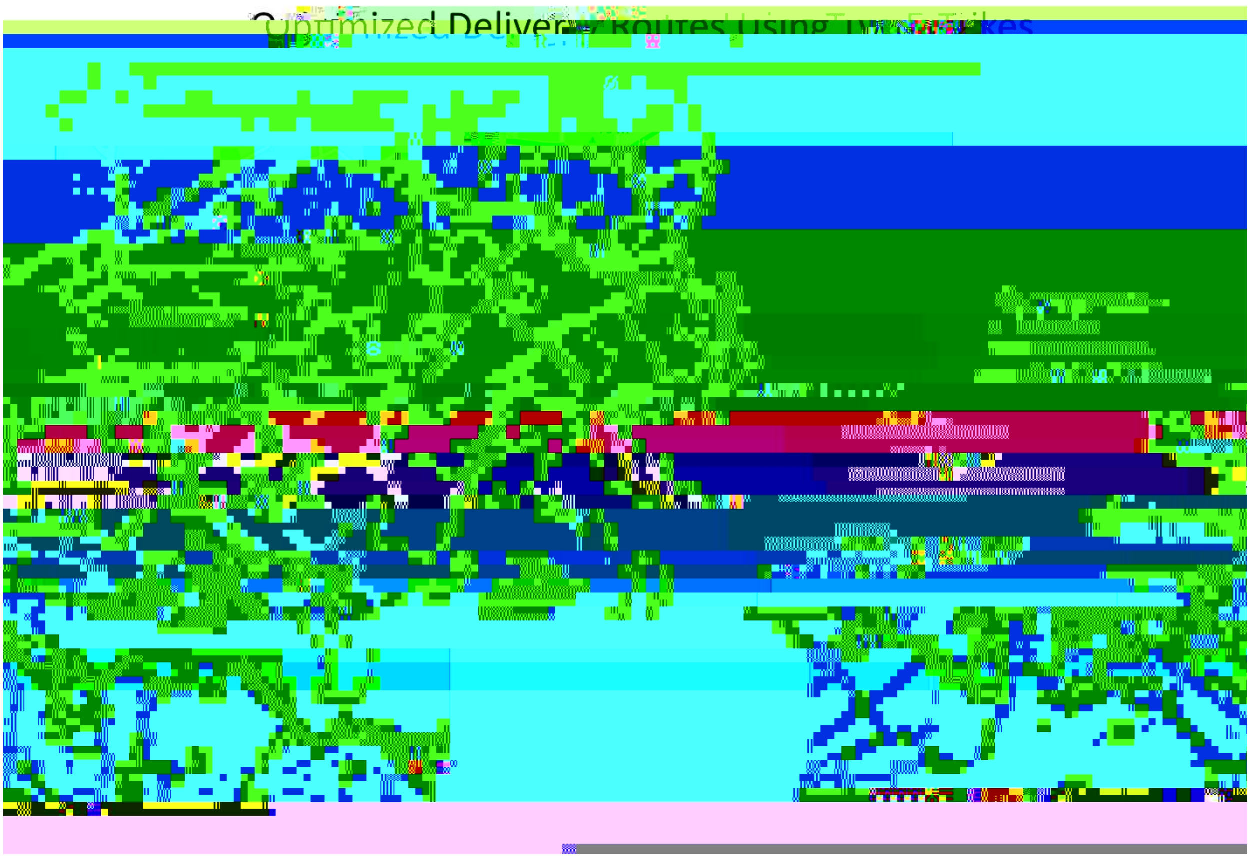

Figure E1. Map of optimized e-trike delivery route to sample week Toha Kai locations using two e-trikes. This analysis was undertaken using Vehicle Routing Problem Analysis.

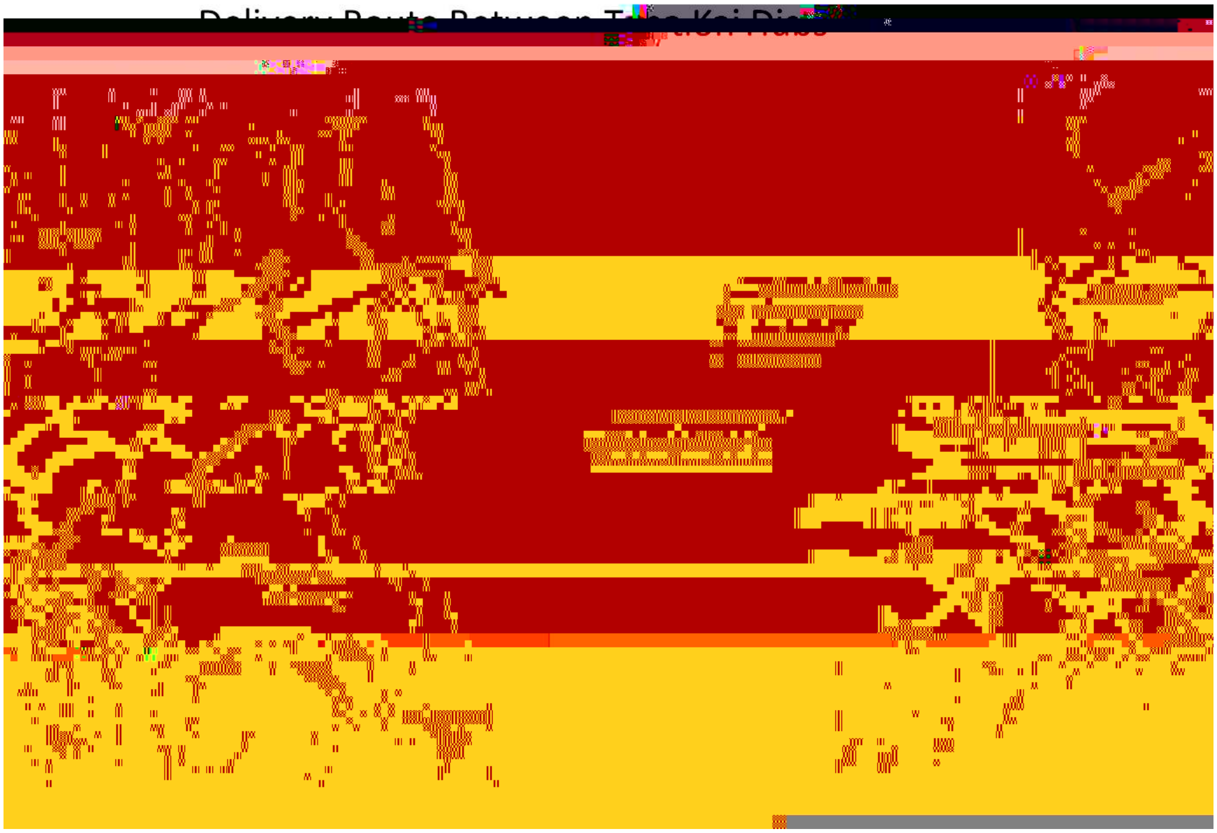

Figure E2. Map of optimized e-trike route which services the pick-up hubs only. This was achieved with route analysis that used the current Toha Kai distribution hubs as stops.

Figure E3. Map of distance-