



CENTRE FOR TRANSPORT STUDIES  
MASTER OF SCIENCE IN ENGINEERING SPECIALISING IN CIVIL ENGINEERING

# Investigation into the Effects of Non-Motorised Transport Facility Implementations and Upgrades in Urban South Africa

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MAJOR DISSERTATION (CIV5000Z)



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*Cover Picture: Pedestrian Facilities Upgrade in the Cape Town CBD*

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## ABSTRACT

Non-motorised Transport (NMT), as a mode of transport, is beneficial and sustainable for both developing and developed countries. In urban areas of South Africa, NMT users face various challenges that reduce the attractiveness of selecting NMT trips. Two main concerns are the high risk of injury (or death) and the inadequate provision of NMT facilities, making NMT trips inefficient and dangerous.

One strategy of addressing these two challenges is implementing NMT facilities that provide safe, convenient and comfortable routes for NMT users. By improving the quality of NMT facilities and increasing the number of NMT facilities available to NMT users, the quality of service that NMT users experience will increase, while at the same time reducing the levels of concerns regarding safety of NMT trips. These changes should result in fewer NMT fatalities and injuries, and consequently, increase the number and quality of NMT trips.

While research in other countries has shown that NMT facilities do indeed have these impacts on NMT trips and NMT fatalities and injuries, limited or no research has been conducted to show that NMT facilities have similar effects in the urban areas of South Africa. This research, therefore, aims to fill this gap in the literature, by investigating the effects that NMT facilities and implementations have in case study areas in urban South Africa.

To investigate the impact that NMT facilities have, in urban areas of South Africa, various investigations and case study infrastructure assessments were carried out. A mixed-methods multi-case study research approach was adopted, in order to combine all the various investigations within one research approach. After identifying the NMT facility implementations that had been implemented, a number of case study and control areas were defined. Data regarding the NMT fatalities and injuries in these areas was then identified and used to calculate the trends within the case study areas and the control areas. Additionally, data from the National Household Travel Surveys (NHTS, 2003 and 2013) helped to determine the changes in the number of NMT trips on a provincial level, as well as within the case study and control areas within Cape Town. The last part of the research, used the information, of where the NMT facility implementations took place, alongside infrastructure assessments to determine whether the quality of the NMT facilities had been improved or not. The findings of all the investigations and assessments were then discussed in a SWOT analysis, which could be used in future decisions regarding the implementations of NMT facilities.

Results of the investigations carried out in this research indicate that NMT facilities do have significant impacts on improving the levels of safety for both pedestrians and cyclists in urban South African settlements. Furthermore, the results of the investigations and assessments show that the quality of service for NMT users will also increase through improvements to the NMT facilities. Additionally, it was found that the quality of the design and implementation of the NMT facility heavily impacts on whether the NMT facilities are able to generate their associated benefits. However,

while some NMT facility implementations have improved the level of service to NMT users, based on the principles within the NMT Facility Guidelines of South Africa (NDoT, 2015), there is much room for improvement in design and implementation of NMT facilities so that the maximum benefit from NMT facilities can be generated. Most noticeable was the difference in the level of success between pedestrians and cyclists. In all of the investigations of this research the effective benefits that the NMT facilities were able to support for pedestrians were far greater than those of cyclists. This indicates that the current NMT facilities are not adequately serving cyclists and greater understanding of implementing NMT facilities for cyclists needs to be developed for urban areas in South Africa. This and the other conclusions are based on the findings of the case study infrastructure assessments and quantitative investigations.

## SUMMARY

The main motivating reason for this research was to determine the impact that NMT (Non-motorised Transport) facilities have in urban areas of South Africa. In South Africa, the main type of NMT users are pedestrians (majority type) and cyclists (minority type). This research aimed to increase the understanding of the effectiveness of NMT facility implementations in urban areas of South Africa. Thus, helping government, stakeholders and practitioners to make better informed decisions when addressing the transport challenges of NMT users in urban areas. The research focused on the two major challenges facing NMT users, namely improving (road) safety and providing adequate facilities to cater for NMT users. The scope of the research was limited to NMT, as a mode of transport in urban areas. Cape Town being used as a case study of an urban South African city. To understand what the potential value NMT trips could be for South Africa, the various benefits that have been documented in various countries are presented.

## BENEFITS OF NON-MOTORISED TRANSPORT: WHY INVESTIGATE THIS MODE OF TRANSPORT

There are various benefits to NMT as a mode of transport. Safety benefits of successful NMT facilities include lower risk of road collisions, injuries and fatalities, while there are also several health benefits of NMT trips, which include lowered levels of stress, obesity and other Non-Communicable Diseases (NCDs). NMT, as a mode of transport, is one of the most sustainable modes of transport, as it does not rely on fuel and, is one of the cleanest modes of transportation. Additionally, NMT trips have various socio-economic benefits that help to address equality concerns, which are highly relevant for urban (and rural) South Africa. An example, of how improved NMT trips could address equality issues, would be increasing the mobility and accessibility of vulnerable members of society. This can be for socio-economic reasons or physical and mental abilities that influence the individual's ability to commute.

The types of designs that influence the success of NMT trips and the NMT facilities include crossing facilities, link facilities, and amenities. The design of facilities can vary, depending on the local context of the surrounding areas, the types of users and the available resources. The Netherlands is presented as an example of the benefits and impacts that NMT trips and NMT facilities can have if done with best practices.

## REFLECTION OF NON-MOTORISED TRANSPORT IN URBAN AREAS OF SOUTH AFRICA

In order to understand NMT, as a mode of transport in South Africa, the challenges facing NMT and the NMT frameworks of South Africa are discussed. The country has several inherited structural challenges that include a trend of decreasing densities of urban settlements, along with social inequalities and highly skewed levels of access and mobility. The most vulnerable members of South Africa currently carry the majority of the transportation costs and inconveniences.

In contrast, the established frameworks that influence South African transportation, are supportive of NMT users and NMT trips. However, the different strategies that have so far been employed to translation the frameworks into practice, have had limited success. Furthermore, implementing NMT facilities as a manner of supporting NMT trips has been largely neglected in South Africa.

## RESEARCH METHOD

In order to determine the impacts of NMT facilities in urban South Africa, areas in Cape Town were selected as case study areas, with various recent NMT facility implementations identified. Control areas were also identified and examined to account for the trends of NMT trips and NMT collision numbers in areas without recent NMT facility implementations. Once appropriate data and information regarding these implementations were identified various investigations into the impact of NMT upgrades and implementations on the case study areas were conducted. The identified data included both National Household Travel Surveys (STATSSA, 2003 and 2013), road collision data (TCT, 2014) and information of recent NMT facility implementation projects in Cape Town (City of Cape Town, 2015). The investigations and assessments had a mixed methods approach, which provided allowed for a multi-perspective on the impacts that NMT facilities had for both pedestrians and cyclists.

## QUANTITATIVE INVESTIGATIONS

In the quantitative investigations, the number of NMT fatalities and injuries were investigated by converting the road collision data into Equivalent Accident Numbers (EANs). From these numbers converted numbers, trends illustrating the safety of NMT users were generated. The changes in the EANs were tested statistically to determine whether the changes were significant or not. Various T-Tests were used in these statistical analyses. This particular quantitative investigation answered the research questions regarding the safety benefits of implementing NMT facilities. It was determined that overall, NMT facilities did have a significant impact on improving the safety of NMT users. For pedestrians the impact that NMT facilities had in improving safety was larger than the impact that NMT facilities had for cyclists.

The other quantitative investigation focused on the trends of NMT trips on a national level, as well as within the Cape Town case study areas, shown in section 5.2.3.2. This helped to determine whether the NMT facilities also helped to encourage the volume of NMT trips. The results from the investigations showed that on a national level NMT trips were on a decline. From the results within the Cape Town area, this also held true for the control areas of the pedestrians, while the Cape Town case study areas of pedestrians indicated that the NMT facilities had a clear positive impact on increasing the number of NMT trips. However, for cyclists, the NMT facilities did not seem to generate any impact on the number of cycling trips. Case study and control areas showed decreasing percentages of cycling trips, which were aligned with national trends of cycling. The results of the quantitative investigations were then used to select the best and worst performing areas for both pedestrian and cyclists. These areas were then investigated in the case study infrastructure assessments.

## CASE STUDY INFRASTRUCTURE ASSESSMENTS

The focus of the infrastructure assessments were to determine how successfully NMT facilities were being implemented from a design and practical perspective. In order to carry this evaluation out, the recently revised NMT Facility Guidelines (NDoT, 2015) were used to generate a rubric, which was then used to rate the various NMT facilities in the best and worst performing case study and control areas for both pedestrians and cyclists. From the infrastructure assessments, key short-comings of the current NMT facilities were identified, as well as the aspects of the facilities that were successfully implemented. Overall, the quality of the designs and implementation could be greatly improved upon in urban areas of South Africa based on fundamental principles as described in the guidelines. Additionally, the facilities implemented varied considerable in terms of designs used, implementation quality and maintenance level. While some facilities were rated as reasonable, all of the implementations were isolated from connecting to other facilities, thereby hindering NMT trips.

## CONCLUSIONS

The most important result from this research is that NMT facilities do have the capacity to make significant improvements for NMT users. Furthermore, in areas that have received implementations, the positive impact for pedestrians has been significant and clearly relates to the investments in NMT facilities. However, for cyclists the investment in NMT facilities has proved to be less effective. This may be, due to the poor quality of NMT facilities that have been implemented for cyclists, which were often shown to be un-useable, impractical or non-existent. This indicates that there is a need in South Africa, to develop the technical skills and knowledge of designing and implementing effective cycling facilities. However, both pedestrian and cyclist facilities need to be improved upon, as demonstrated in the quantitative investigations.

Additionally, considering the small number of NMT facilities and the fragmented nature of the NMT networks in urban areas of Cape Town, there is significant need to increase the number of NMT facilities and the level of connectivity of the NMT networks, especially for cycling infrastructure.

Further research into NMT trips and NMT facilities is needed in South Africa. One recommendation would be to explore the relationships between NMT modes and public transport modes, in order to understand how best to integrate NMT trips with public transport trips in urban areas of South Africa, thereby increasing the practicality of making NMT trips and supporting the various public transport projects in South Africa.





## TABLE OF CONTENTS

Acknowledgements.....	i
Abstract.....	ii
Summary.....	iv
Benefits of Non-Motorised Transport: Why Investigate this Mode of Transport .....	iv
Reflection of Non-Motorised Transport in Urban Areas of South Africa .....	iv
Research Method .....	v
Quantitative Investigations .....	v
Case Study Infrastructure Assessments .....	vi
Conclusions.....	vi
List of Figures .....	xi
List of Tables .....	xv
List of Map.....	xvii
1. Introduction.....	1
1.1 Background of Non-Motorised Transport as a Mode of Transport.....	1
1.2 Problem to be Investigated.....	2
1.2.1 Road Safety Challenge.....	2
1.2.2 The Challenge of Providing Adequate Non-Motorised Transport Facilities.....	3
1.3 Purpose of the Study .....	6
1.3.1 Proposition 1: Determining Improvements of Non-Motorised Transport Facilities .....	7
1.3.2 Proposition 2: Safety of Non-Motorised Transport Users .....	7
1.3.3 Proposition 3: Non-Motorised Transport Trips .....	7
1.3.4 Proposition 4: Quality of Non-Motorised Transport Facilities.....	8
1.4 Scope and Limitations.....	8
1.5 Thesis Structure .....	9
2. Benefits of NMT: Why Investigate this Mode of Transport.....	10
2.1 Benefits of Non-Motorised Transport and Non-Motorised Transport Facilities.....	10
2.1.1. Safety Benefits of Non-Motorised Transport .....	11
2.1.2. Health Benefits of Non-Motorised Transport.....	13
2.1.3. Environmental and Sustainability Benefits of Non-Motorised Transport.....	14



2.1.4. Equality and Socio-Economic Benefits of Non-Motorised Transport.....	15
2.2 Non-Motorised Transport Facilities: Types and Designs .....	17
2.2.1 Pedestrian Facilities .....	19
2.2.1.1 Pedestrian Crossing Facilities .....	19
2.2.1.2 Pedestrian Link Facilities.....	31
2.2.1.3 Pedestrian Amenities .....	32
2.2.2 Cycling Facilities .....	32
2.2.2.1 Cycling Crossing Facilities .....	32
2.2.2.2 Cycling Link Facilities.....	33
2.2.2.3 Cycling Amenities .....	34
2.3 A Non-Motorised Transport Example: The Netherlands.....	35
3. Reflection of South African Non-Motorised Transport.....	38
3.1 Inherited Structural Challenges in South Africa.....	38
3.2 Frameworks of South African Non-Motorised Transport .....	41
3.3 Key Strategies of Non-Motorised Transport.....	44
3.3.1 Key Strategy 1: Supporting Legislation, Policy, Strategies and Guidelines.....	45
3.3.2 Key Strategy 2: Non-Motorised Transport Facilities Implementations.....	47
3.3.3 Key Strategy 3: Education, Encouragement and Rights of Non-Motorised Transport Users ..	49
3.4 Unrealised Potential of Non-Motorised Transport in South Africa.....	50
3.4.1 Safety Benefits for South Africa.....	50
3.4.2 Health Benefits for South Africa .....	51
3.4.3 Environmental Benefits for South Africa .....	53
3.4.4 Equality and Socio-Economic Benefits for South Africa .....	53
3.5 Non-Motorised Transport Facilities: Identified Key Approach.....	55
4. Research Method .....	55
4.1 Method Outline .....	56
4.2 Case Study Design for the Research.....	57
4.2.1 Conceptual Framework.....	59
4.2.2 Linking Data to Propositions .....	60



4.2.3 Criteria for Interpreting Findings.....	61
4.3 Types of Data.....	61
4.4 Flow Diagram of Research Method.....	62
5. Quantitative Investigations .....	67
5.1 Non-Motorised Transport Fatalities and Injuries Investigation.....	67
5.1.1 A Quantitative Approach for Non-Motorised Transport Safety Investigation .....	68
5.1.2 The Quantitative Method of Research for Non-Motorised Transport Safety .....	71
5.1.3 Findings and Discussion for Non-Motorised Transport Safety .....	72
5.1.3.1 Pedestrian Investigation Findings and Discussions .....	72
5.1.3.2 Cyclist Investigation Findings and Discussions .....	77
5.2 Non-Motorised Transport Trips Investigation.....	81
5.2.1 Quantitative Investigation Approach .....	82
5.2.2 Quantitative Method of Research .....	86
5.2.3 Quantitative Investigation Findings and Discussion .....	86
5.2.3.1 General Changes in Non-Motorised Transport Trips in South Africa.....	86
5.2.3.2 Changes of Non-Motorised Transport Trips in Investigated Areas of Cape Town.....	90
6. Case Study Infrastructure Assessments .....	93
6.1 Infrastructure Assessments Approach and Method of Research .....	93
6.1.1 Step 1: Identification of Routes and Facilities .....	94
6.1.2 Step 2: Drafting of Case Study Infrastructure Assessment Rubric.....	96
6.1.3 Step 3: Gathering of Images of Routes .....	96
6.1.4 Step 4: Ratings of Non-Motorised Transport Facilities on Selected Routes .....	98
6.1.4.1 Case Study Areas .....	99
6.1.4.2 Control Areas.....	113
6.2 Case Study Infrastructure Assessment Findings and Discussion .....	121
6.2.1 SWOT Analysis of Investigations: Strengths .....	122
6.2.2 SWOT Analysis of Investigations: Weaknesses.....	122
6.2.3 SWOT Analysis of Investigations: Opportunities .....	123
6.2.4 SWOT Analysis of Investigations: Threats .....	123



7. Conclusions.....	125
7.1 Summary of Proposition 1 .....	125
7.2 Summary of Proposition 2 .....	128
7.3 Summary of Proposition 3 .....	129
7.4 Summary of Proposition 4 .....	130
7.6 Recommendations for Further Research in this Area of Non-Motorised Transport .....	131
Appendix A: Grouping of Non-Motorised Transport Facility Projects.....	140
Appendix B: Pedestrian Equivalent Accident Number Graphs .....	142
B.1 Case Study Areas .....	142
B.2 Control Study Areas .....	148
Appendix C: Cyclist Equivalent Accident Number.....	153
C.1 Case Study Areas .....	153
C.2 Control Study Areas .....	159
Appendix D: T-Tests.....	164
D.1 Pedestrian Case Study vs Control Area .....	164
D.2 Pedestrian Case Study Areas.....	164
D.3 Pedestrian Control Areas .....	169
D.4 Cyclist Case Study vs Control Area.....	172
D.5 Cyclist Case Study Areas .....	173
D.6 Cyclist Control Areas.....	178
Appendix E: Locations of Selected Areas for Case Study Infrastructure Assessments .....	181
Appendix F: Ethics Form.....	187

## LIST OF FIGURES

Figure 1: Cyclist Casualties and Bicycle Use in Bogotá, 2003-2013 .....	12
Figure 2: Physical Context of Non-Motorised Transport Facilities .....	18
Figure 3: Part 1 of Requirements for Non-Motorised Transport Users with Special Needs .....	20
Figure 4: Part 2 of Requirements for Non-Motorised Transport Users with Special Needs .....	21
Figure 5: Pedestrian Midblock Controlled Crossing Facility .....	23
Figure 6: Smaller Radii; Desire Lines and Sight Distances .....	24
Figure 7: Large Radii; Desire Lines and Sight Distances .....	24
Figure 8: Example of a Pedestrian User-Friendly Intelligent Crossing design .....	25
Figure 9: Example of Pedestrianised Street .....	26
Figure 10: Pedestrian Facilities for Controlled Intersections .....	27
Figure 11: Cable-Cars of Line K .....	29
Figure 12: Underpass Design .....	30
Figure 13: Example of Warning Sign of Security Risk of using Pedestrian Facility, Claremont Railway Station, South Africa .....	30
Figure 14: Example of a Bike Box Design .....	33
Figure 15: Bicycle Path with Full Priority .....	34
Figure 16: Cycling Fatality Rates and Annual Kilometres Cycled per Person, The Netherlands .....	36
Figure 17: Population Growth of Cape Town 1904-2000 .....	40
Figure 18: Non-Motorised Transport Strategy for the City of Cape Town .....	46
Figure 19: Conceptual Framework for Research: Safety and Usage of Non-Motorised Transport Users .....	59
Figure 20: Flow Diagram of Method .....	63
Figure 21: Case Study Areas with Non-Motorised Transport Facility Upgrade Lengths .....	68
Figure 22: Locations of Case Study and Control Areas indicated with Markers .....	70
Figure 23: Total Pedestrian Equivalent Accident Number Trends for Case Study and Control Areas .....	74
Figure 24: Cyclist Equivalent Accident Numbers in Case Study Areas .....	78
Figure 25: Cyclist Equivalent Accident Numbers in Control Areas .....	79
Figure 26: Change of the Workers Who Walked All the Way per Province .....	87
Figure 27: Change of the Learners Who Walked All the Way per Province .....	88



Figure 28: Change of Walking Trips in Traffic Analysis Zones of Case Study and Control Areas .....	91
Figure 29: Change of Cycling Trips in Traffic Analysis Zones of Case Study and Control Areas .....	92
Figure 30: Locations of Case Study and Control Areas shown with Markers .....	95
Figure 31: Mitchells Plain Non-Motorised Transport Facilities .....	99
Figure 32: Weltevreden Parkway Infrastructure Assessment .....	100
Figure 33: Merrydale Ave Infrastructure Assessment .....	101
Figure 34: Dieprivier Non-Motorised Transport Facilities .....	102
Figure 35: M38 Infrastructure Assessment .....	103
Figure 36: M38 Infrastructure Assessment .....	104
Figure 37: M38 Infrastructure Assessment .....	104
Figure 38: Khayelitsha Non-Motorised Transport Facilities .....	105
Figure 39: Spine Road Infrastructure Assessment .....	106
Figure 40: Spine Road Infrastructure Assessment .....	107
Figure 41: M45 Infrastructure Assessment .....	108
Figure 42: M45 Infrastructure Assessment .....	109
Figure 43: Sea Point Non-Motorised Transport Facilities .....	110
Figure 44: Sea Point Infrastructure Assessment .....	111
Figure 45: Sea Point Infrastructure Assessment .....	112
Figure 46: Philippi with Selected Route .....	113
Figure 47: Philippi Infrastructure Assessment .....	114
Figure 48: Bishop Lavis with Selected Roads .....	115
Figure 49: Intersection of M10 and Heilbot Road Infrastructure Assessment .....	116
Figure 50: Melton Road Infrastructure Assessment .....	117
Figure 51: Kirstenhof with Selected Roads .....	118
Figure 52: Tokai Road Infrastructure Assessment .....	119
Figure 53: Tokai Road at an Intersection Infrastructure Assessment .....	119
Figure 54: Typical Roads surround the School Infrastructure Assessment .....	120
Figure 55: Equivalent Accident Numbers of Pedestrian Case Study Areas .....	142
Figure 56: Total of all Pedestrian Equivalent Accident Number of Case Study Areas .....	143



Figure 57: Pedestrian Equivalent Accident Number of Atlantis with Block indicating Facility Upgrades .....	143
Figure 58: Pedestrian Equivalent Accident Number of Langa with Block indicating Facility Upgrades .....	144
Figure 59: Pedestrian Equivalent Accident Number of Gugulethu with Blocks indicating Facility Upgrades .....	144
Figure 60: Pedestrian Equivalent Accident Number of Steenberg with Block indicating Facility Upgrades .....	145
Figure 61: Pedestrian Equivalent Accident Number of Mitchell's Plain with Block indicating Facility Upgrades .....	145
Figure 62: Pedestrian Equivalent Accident Number of Dieprivier with Block indicating Facility Upgrades .....	146
Figure 63: Pedestrian Equivalent Accident Number of Khayelitsha with Block indicating Facility Upgrades .....	146
Figure 64: Pedestrian Equivalent Accident Number of Sea Point with Block indicating Facility Upgrades .....	147
Figure 65: Pedestrian Equivalent Accident Number of Cape Town's CBD with Block indicating Facility Upgrades .....	147
Figure 66: Pedestrian Equivalent Accident Number of Milnerton with Block indicating Facility Upgrades .....	148
Figure 67: Pedestrian Equivalent Accident Number of Control Areas.....	148
Figure 68: Total Pedestrian Equivalent Accident Number of Control Areas .....	149
Figure 69: Pedestrian Equivalent Accident Number of Philippi .....	149
Figure 70: Pedestrian Equivalent Accident Number of Bishop Lavis.....	150
Figure 71: Pedestrian Equivalent Accident Number of Ravensmead.....	150
Figure 72: Pedestrian Equivalent Accident Number of Kirstenhof.....	151
Figure 73: Pedestrian Equivalent Accident Number of Camps Bay.....	151
Figure 74: Pedestrian Equivalent Accident Number of Bothasig.....	152
Figure 75: Equivalent Accident Number of Cyclists for Case Study Areas.....	153
Figure 76: Total Equivalent Accident Number of Cyclists for Case Study Areas .....	154
Figure 77: Cyclist Equivalent Accident Number of Atlantis with Block Indicating Facility Upgrades .....	154

Figure 78: Cyclist Equivalent Accident Number of Langa with Block indicating Facility Upgrades	155
Figure 79: Cyclist Equivalent Accident Number of Gugulethu with Blocks indicating Facility Upgrades .....	155
Figure 80: Cyclist Equivalent Accident Number of Steenberg with Block indicating Facility Upgrades .....	156
Figure 81: Cyclist Equivalent Accident Number of Mitchells Plain with block indicating Facility Upgrades .....	156
Figure 82: Cyclist Equivalent Accident Number of Dieprivier with Block indicating Facility Upgrades .....	157
Figure 83: Cyclist Equivalent Accident Number of Khayelitsha with Block indicating Facility Upgrades .....	157
Figure 84: Cyclist Equivalent Accident Number of Sea Point with Block indicating Facility Upgrades .....	158
Figure 85: Cyclist Equivalent Accident Number of CBD with Block indicating Facility Upgrades ..	158
Figure 86: Cyclist Equivalent Accident Number of Milnerton with Block indicating Facility Upgrades .....	159
Figure 87: Cyclist Equivalent Accident Number of Control Areas .....	159
Figure 88: Total Cyclist Equivalent Accident Number of Control Areas .....	160
Figure 89: Cyclist Equivalent Accident Number of Philippi.....	160
Figure 90: Cyclist Equivalent Accident Number of Bishop Lavis .....	161
Figure 91: Cyclist Equivalent Accident Number of Ravensmead .....	161
Figure 92: Cyclist Equivalent Accident Number of Ravensmead .....	162
Figure 93: Cyclist Equivalent Accident Number of Camps Bay .....	162
Figure 94: Cyclist Equivalent Accident Number of Bothasig .....	163
Figure 95: Location of the Case Study Area of Mitchells Plain, with the Control Area of Philippi Adjacent .....	181
Figure 96: Location of Case Study Area Dieprivier .....	182
Figure 97: South Section of Case Study Area Dieprivier Showing Area of Control Area Kirstenhof	183
Figure 98: Location of Case Study Area Khayelitsha with Control Area Philippi.....	183
Figure 99: Location of Case Study Area Sea Point with Control Area of Camps Bay .....	184
Figure 100: Control area Philippi with Case Study Area of Mitchells Plain and Khayelitsha .....	184
Figure 101: Control Area Bishop Lavis with Case Study Area of Gugulethu.....	185





Figure 102: Location of Control Area Kirstenhof, Situated South of Case Study Area Dieprivier ....	186
Figure 103: Location of Control Area Bothasig .....	186

## LIST OF TABLES

Table 1: Reference Table of Literature for Key Strategies and Initiatives .....	45
Table 2: Summary of Case Study Structure.....	57
Table 3: Coefficient of Determinations for Different Case Study Areas.....	73
Table 4: Summary of T-Test Results per Case Study Areas for Pedestrians.....	76
Table 5: Summary of T-Test Results per Control Areas for Pedestrians .....	76
Table 6: T-Test between Case Study Areas and Control Areas.....	77
Table 7: Coefficient of Determinations for Different Case Study Areas.....	78
Table 8: Summary of T-Test Results per Case Study Area for Cyclist Equivalent Accident Number .	80
Table 9: Summary of T-Test Results per Control Area for Cyclist Equivalent Accident Number .....	81
Table 10: Number of Areas per Traffic Analysis Zone in National Household Travel Survey .....	83
Table 11: Factors that are prioritised in Selection of Transportation Modes .....	89
Table 12: Relative Changes in Equivalent Accident Numbers for Pedestrians and Cyclists .....	94
Table 13: Relative Changes in Equivalent Accident Numbers for Pedestrians and Cyclists .....	95
Table 14: Infrastructure Assessment Ratings for Non-Motorised Transport Facilities.....	97
Table 15: Resulting Ratings of the Selected Routes in the Case Study and Control Areas .....	98
Table 16: Average Scores per Principle for Case Study and Control Routes.....	121
Table 17: T-Test for Pedestrian Case Study and Control Areas between 2008 and 2013.....	164
Table 18: T-Test for Atlantis for Implementations in 2012/13.....	164
Table 19: T-Test for Langa for Implementations in 2011/13 .....	165
Table 20: T-Test for Gugulethu for Implementations in 2008/09 vs 2012/13.....	165
Table 21: T-Test for Steenberg for Implementations in 2012/14 .....	166
Table 22: T-Test for Mitchells Plain for Implementations in 2012/13.....	166
Table 23: T-Test for Dieprivier for Implementations in 2012/13.....	167
Table 24: T-Test for Khayelitsha for Implementations in 2008/09 vs 2012/13 .....	167
Table 25: T-Test for Sea Point for Implementations in 2008/09 vs 2012/13 .....	168



Table 26: T-Test for CBD for Implementations in 2010/12 .....	168
Table 27: T-Test for Milnerton for Implementations in 2011/12 .....	169
Table 28: T-Test for Philippi for Implementations in 2008/09 vs 2012/13 .....	169
Table 29: T-Test for Bishop Lavis for Implementations in 2008/09 vs 2012/13 .....	170
Table 30: T-Test for Ravensmead for Implementations in 2008/09 vs 2012/13 .....	170
Table 31: T-Test for Kirstenhof for implementations in 2008/09 vs 2012/13 .....	171
Table 32: T-Test for Camps Bay for implementations in 2008/09 vs 2012/13 .....	171
Table 33: T-Test for Bothasig for implementations in 2008/09 vs 2012/13 .....	172
Table 34: T-Test for Cyclist Case Study and Control Areas from 2009 to 2013 .....	172
Table 35: T-Test for Atlantis for Implementations in 2012/13 .....	173
Table 36: T-Test for Langa for Implementations in 2011/13 .....	173
Table 37: T-Test for Gugulethu for Implementations in 2009/10 vs 2012/13 .....	174
Table 38: T-Test for Steenberg for Implementations in 2012/14 .....	174
Table 39: T-Test for Mitchells Plain for Implementations in 2012/13 .....	175
Table 40: T-Test for Dieprivier for Implementations in 2012/13 .....	175
Table 41: T-Test for Khayelitsha for Implementations in 2009/10 vs 2012/13 .....	176
Table 42: T-Test for Sea Point for Implementations in 2009/10 vs 2012/13 .....	176
Table 43: T-Test for CBD for Implementations in 2010/12 .....	177
Table 44: T-Test for Milnerton for Implementations in 2011/12 .....	177
Table 45: T-Test for Philippi for Implementations in 2009/10 vs 2012/13 .....	178
Table 46: T-Test for Bishop Lavis for Implementations in 2009/10 vs 2012/13 .....	178
Table 47: T-Test for Ravensmead for Implementations in 2009/10 vs 2012/13 .....	179
Table 48: T-Test for Kirstenhof for Implementations in 2009/10 vs 2012/13 .....	179
Table 49: T-Test for Camps Bay for Implementations in 2009/10 vs 2012/13 .....	180
Table 50: T-Test for Bothasig for Implementations in 2009/10 vs 2012/13 .....	180



## LIST OF MAPS

Map 1: Overview of Case Study and Control Areas with TAZs of the NHTS .....	84
Map 2: Detailed View of Case Study and Control Areas .....	85

# 1 INTRODUCTION

## 1.1 BACKGROUND OF NON-MOTORISED TRANSPORT AS A MODE OF TRANSPORT

Non-Motorised Transport (NMT), generally, refers to any mode of transport that relies on energy, which is not generated by an engine (NDoT, 2015). A common example of this type of energy would be walking or cycling using human effort as an energy source. The majority of South Africans cannot afford a private motor vehicle and are dependent on either NMT trips or Public Transport (PT) trips for mobility and accessibility (Walters, 2008). NMT trips, therefore, fulfil an important travel demand for South Africans (NDoT, 2015). In most South Africans trips, there is at least one component of the trip that is fulfilled through NMT trips (usually walking). NMT trips, generally, act either as a feeder mode by providing access to PT or as the dominant mode of transport by fulfilling the entire travel need (STATSSA, 2013). However, despite playing an integral part in transport, adequate understanding of NMT trips and its facilities, in order to successfully address the challenges for NMT users, are not well-established in South Africa, both in practice and on a policy level (NDoT, 2008; Ribbens, 2008; Beukes *et al.*, 2012).

NMT, as a mode of transport, refers to a much broader range of modes other than walking. This includes bicycling, skateboarding, horse riding (and other similar animals) or using animals to power movement, through the use of carts and trailers (NDoT, 2015). While there are various types of NMT users in South Africa, pedestrians are by far the dominant NMT user type, followed by a much smaller but still important cycling proportion (NDoT, 2008). Consequently, the research focuses on walking and cycling and the facilities related to these two types of NMT modes.

The National Department of Transport (NDoT) has recognised the need to address the numerous challenges that face NMT users in South Africa (NDoT, 2008). These challenges range from security and safety of NMT users and distances of trips (especially to public transport stations). One of the main ways they sort to address these challenges was to implement adequate NMT facilities (NDoT, 2008; Pucher and Buehler, 2008). The term “NMT facility” can refer to a number of physical elements: from pedestrian pavements to exclusive bike lanes, prioritised signalled crossings, as well as street lighting and signage (NDoT, 2015). Recently, the NDoT identified that there was a lack of suitable guidelines for NMT facilities, which is an important contributing factor to the challenges facing NMT users in South Africa. The lack of adequate NMT facilities is acknowledged as contributing to low levels of service regarding NMT trips (Ribbens, 2008; NDoT, 2015). A set of updated and expanded NMT guidelines have consequently been drafted and implemented (NDoT, 2015). The guidelines suggest an increased focus on practical designs and principles guiding implementation. An example of such a principle is Universal Access (UA) and the associated Universal Design (UD) principles proposed initially by Mace (1997) that have now been included into

the NMT Facility guidelines. The guidelines aim to improve the quality of the designs and, therefore, the implementation of NMT facilities in South Africa. Emphasis within the new NMT facility guidelines was placed on providing a more comprehensive range of solutions and designs to address a wider range of situations for different settlement and user types. For example, guidelines that would be appropriate for urban areas would have to differ for rural areas, as the diverse environments have different challenges and requirements (Beukes *et al.*, 2012; NDoT, 2015). Other considerations of varying requirements include areas with different land uses (for example, schools) and, vulnerable or sensitive users such as children, women, older persons and users with disabilities.

## 1.2 PROBLEM TO BE INVESTIGATED

There are various challenges facing NMT, as a mode of transport, in urban areas of South Africa, which include issues related to policy, strategies and budgeting for NMT facilities and programs, as well as poor education and training for both NMT and other road users. External challenges that affect NMT trips include poor enforcement of road regulations, security concerns (crime), the lack of integration between NMT facilities and other modes of transport facilities, as well as land use planning that does not support NMT, as a mode of transport.

Two key aspects of urban South African NMT trips have been highlighted as being directly problematic for NMT, as a mode of transport (Vanderschuren and Galaria, 2003; Ribbens, 2008). Firstly, roads in urban areas of South Africa are unsafe for NMT users. Secondly, NMT trips are not attractive to South Africans. These two challenges to improving NMT trips are cited in both the literature that was reviewed (Vanderschuren and Galaria, 2003; Pucher and Buehler, 2008; Ribbens, 2008; Dill, 2009; Verma *et al.*, 2015), as well as through stakeholder engagements during the drafting of the new NMT Facility Guidelines. The two described challenges seem to be systemic to South African NMT trips and have far reaching implications for South Africa, which will be discussed later in Chapter 3.

### 1.2.1 ROAD SAFETY CHALLENGE

The challenge of improving NMT safety is a significant obstacle to be overcome. However, South Africa is not alone in facing this challenge and it is, indeed, a common challenge in both developed (Jacobsen, 2003; Pucher and Buehler, 2008; Ribbens, 2008; Garrard *et al.*, 2008), and developing countries (Maunder and Fouracre, 1989; Peden *et al.*, 2013). Due to various contributing causes and factors, the challenges facing NMT, as a mode of transport, are generally much greater in developing countries, where NMT trips are often not acknowledged as an important mode of transport and is, therefore, not sufficiently planned and designed for and not implemented either. These challenges are seen in South Africa, where many areas of the country lack adequate NMT facilities, and the country as a whole has one of the highest road fatalities and injuries rates in the world (MacKenzie *et al.*, 2008; STATS SA, 2009; NDoT, 2014a). In South Africa, research indicates that there are three main

types of pedestrians that are involved in road collisions (Mabunda *et al.*, 2008). These are described as:

1. Male pedestrians, that showed high blood alcohol concentrations,
2. Female and older pedestrian fatalities, that occurred between 6:00am to midday,
3. Children, adolescents and young adult fatalities that occur during weekday afternoons and evenings.

For motorised road collisions, the main reasons that are given include excessive speeding and alcohol (and drug) abuse whilst driving (STATS SA, 2009). However, while these are the stated reasons for the collisions, this does not necessarily mean that they are the only possible causes. Alternative reasons, which are underlying or are currently unidentified contributing factors, may not be evident from the reports received from the collisions. An indication that this may be the case in South Africa is that, while significant efforts to address speeding and drunk driving have been ongoing for several decades, they have not resulted in substantial reductions in the rates of road collision fatalities and injuries, especially for pedestrian and other NMT users. Various campaigns, such as the Decade of Action for Road Safety, which had aimed at reducing the number of road fatalities and injuries by half (WHO, 2011) have failed to reach targets or demonstrate a noticeable impact. Therefore, contributing reasons for poor road safety that are fundamental to the design and implementation of the transportation network would be appropriate to investigate.

While the annual cost of NMT fatalities and injuries has not been estimated, the total annual direct cost of road collisions in South Africa has been quantified to be R306 billion (Western Cape Government, 2015). Considering that approximately a third of all the fatalities and injuries in South Africa are NMT users (STATS SA, 2009), it is likely that NMT fatalities and injuries contribute a significant cost to South African society. The road collision cost estimate excludes the unaccounted social and emotional costs to families and communities. In a developing society, the social and emotional costs are heightened on a socio-economic level, as the victims are often breadwinners of lower income groups (Behrens, 2004). Through these road collisions, higher levels of inequality, poverty and social exclusion is induced. While the various authorities and stakeholders are attempting to resolve the burden of road collisions through a variety of measures and resources, significant improvements have yet to be made (Ribbens, 2008; STATS SA, 2009).

### 1.2.2 THE CHALLENGE OF PROVIDING ADEQUATE NON-MOTORISED TRANSPORT FACILITIES

The next challenge identified is the inadequate provision of NMT facilities for NMT users, resulting in sub-par levels of service for NMT users. Providing adequate levels of service for NMT users is seen as an important aspect in the literature for other countries (Pucher and Buehler, 2008; Verma *et al.*, 2015), as well as locally (Vanderschuren and Galaria, 2003; NDoT, 2015). In South Africa, the lack of adequate NMT facilities could be seen as hindering the acceptance and support of NMT trips in South

Africa (City of Cape Town, 2009). The current prioritization of NMT facilities seems to be much lower than what is necessary to make substantial progress in terms of providing adequate implementation of facilities, to ensure safe, convenient and comfortable NMT trips in South Africa (Vanderschuren and Galaria, 2003; Behrens, 2004; NDoT, 2015).

There are various potential reasons why there are inadequate facilities. Reasons range from insufficiently trained stakeholders and practitioners, to more basic issues, such as insufficient funding frameworks, that allow for the appropriate NMT facilities to be built and maintained (City of Cape Town, 2009). Local government and municipalities are trying to address the inadequate level of NMT facilities through measures including master plans and guideline (Visser, *et al.*, 2003; City of Cape Town, 2005; Cape Winelands District Municipality, 2009; City of Johannesburg, 2009). However, an integrated NMT approach which takes into account the various stakeholders in both the public and privates environments is still lacking (Vanderschuren and Galaria, 2003; Pretorius, 2015). The lack of an integrated approach can be seen in the many new developments, upgrades of current road facilities and new PT facilities and services not taking into account the needs of NMT users. The NDoT hopes that the newly drafted NMT Facility Guidelines will help address this issue, by encouraging practitioners and stakeholders to include NMT facilities through providing comprehensive and practical guidelines (NDoT, 2015). However, as the guidelines are not legally binding, the effectiveness of this approach is questionable and relies heavily on how the guidelines are distributed and presented, to the relevant stakeholders and general public. Additionally, the relevant stakeholders and practitioners that are responsible for designing and implementing NMT facilities will need to be motivated to adopt the new NMT Facility Guidelines into their work.

The consequences of inadequate provision of NMT facilities include illegal and dangerous travel behaviour (both by NMT users and motorists), as well as increased dependency on motorised transport trips. By not providing adequate facilities for NMT trips, individuals switch to motorised forms of transport as soon these modes are available or affordable for them. Increasing levels of motorised transport is problematic, as it results in increased levels of congestion and the various negative externalities associated with private motorised transportation, as well as resulting in public transport becoming less viable due to declining number of passengers. Additionally, motorised transport use reduces the amount of physical activity of individuals on a daily basis, which further worsens the levels of health of South Africans, which, in turn, increases the cost of health-care for South Africa (City of Cape Town, 2014).

An additional consequence of inadequate NMT facilities is the high level of inequity which is reflected in the space allocation to the different road users (Litman, 2002). Individuals with higher incomes are dominating public road spaces in South Africa with private cars (Behrens, 2004) and vulnerable road users, such as pedestrians and cyclists, are being poorly provided for (City of Cape Town, 2005; City of Cape Town, 2009). Addressing inequality throughout South Africa, especially in the public spaces, is an important aspect of transformation in South Africa (Özler, 2007). In the Constitution of South Africa, as well as the Bill of Rights, improving levels of equality regardless of income, race, age, or



gender is a central theme. Therefore, addressing the needs of NMT users is an important aspect of upholding these rights in a practical manner, which could have significant positive impacts for society as a whole (City of Cape Town, 2009; NDoT, 2008).

The role that NMT facilities have for NMT users has been investigated in other countries (both developed and developing). However, the impacts that NMT facilities currently have, or could potentially have, for South African transport has not been well documented in the literature (Behrens, 2004; Gwala, 2007). The knowledge gap is a potential underlying reason why the implementations of NMT facilities have been slow or non-existent in many areas of the country, as the value of NMT facilities has been underestimated or not properly understood.

By demonstrating the role that NMT facilities have in urban areas of South Africa, this research hopes to highlight the significant impacts that NMT facilities can generate. Local governments and other stakeholders will then be better informed to allocate funds and priorities based on the demonstrated benefits of NMT facilities within the urban South African context. It is the aim of this research to demonstrate that an increased number and quality of NMT facilities will help to address the two challenges of poor NMT safety and poor level of service for NMT users. NMT facilities have a critical role in not only sustaining and improving the level of service that NMT users experience but also an important role in enabling PT trips.

The effects that the implemented NMT facilities have had, in terms of improving safety and satisfying the needs of NMT users, are investigated in this research. The research explains the potentially twofold impact of improving NMT facilities, in terms of both safety and public usage of NMT trips. Firstly, an investigation of whether improved NMT facilities reduce fatalities and injuries of NMT users. Secondly a comparison of the volume of NMT trips in the study areas from 2003 to 2013 is done in order to determine whether there has been an increase of NMT trips in the areas that have had upgrades. Additionally, the actual implementations are assessed to determine how successfully these implementations are, based on the recommendations presented in the new NMT Facility Guidelines (NDoT, 2015). From these three main investigations, the progress and shortcomings of the NMT implementations are established, regarding the impact these NMT implementations and upgrades have had in terms of improving the safety of NMT users as well as increasing usage of the facilities.

Alternative solutions to improving NMT trips in South Africa, which are often encouraged over and above implementing NMT facilities, include bike supply, education or events. While the above mentioned alternatives do have a role in improving NMT trips, they may be ineffective and limited in their success if the physical implementations (NMT facilities) are not in place. An example of where a lack of adequate NMT facilities had a direct impact on the success of one of these alternative measures was a national bicycle supply program of Shova Kula, where a key lesson learnt from that program was the importance of implementation of cycling infrastructure (NDoT, 2008). Recognising the interconnected relationships between NMT users, trips and facilities, the following propositions are proposed:



## Propositions:

1. In Cape Town there has been an increase in the improvements of NMT facilities over the years.
2. In the areas where NMT facilities have improved, the safety of NMT users has improved.
3. NMT improvements have also had a positive impact on the number of NMT trips.
4. The quality of the NMT facilities that have been implemented varies considerably with some facilities being adequate, while others being inadequate.

The correlation between increasing the number of adequate NMT facilities and increased levels of safety and NMT usage has been established in other countries, both developed and developing. The aim of this research is to show that similar results are obtained and can be expected within the urban areas of South Africa.

### 1.3 PURPOSE OF THE STUDY

Currently, there is limited research that demonstrates the value of improving NMT facilities in urban areas of South Africa, or whether NMT implementations have been successful or not, in terms of addressing the major challenges facing NMT users. The gap of knowledge regarding NMT facilities in South Africa could be contributing to the slow or complete lack of implementation that is currently seen in the different parts of the country. One of the goals of this research is to establish the progress made so far regarding NMT facilities in urban areas of South Africa, as well as highlighting best practices that are found.

While data regarding NMT trips and NMT fatalities and injuries in South Africa is scarce, it is hoped that through this study more insight into the current situation using the available data will be uncovered. Combined with the extensive literature review, stakeholder and expert engagements, it is hoped that new links of understanding regarding the challenges that surround NMT trips, and more specifically challenges of implementing successful NMT facilities, will be established.

An important aspect of demonstrating the value of NMT trips in urban areas of South Africa is taking the local factors, influences and perspectives into account. Therefore, demonstrating that the value of NMT facilities that have been documented in other parts of the world applies to South Africa can increase the support and justification of investing in future NMT facilities implementations. However, if the benefit of NMT facilities cannot be demonstrated or if the implementations of NMT facilities do not have the same type of effects, then it will indicate that the context of South Africa has a significant impact on NMT trips. The related implications may mean that implementing NMT facilities in urban areas of South Africa would remain a secondary measure, rather than a primary measure, to addressing the challenges facing NMT users.

Therefore, the following research questions are proposed for each of the four propositions identified previously identified.

### **1.3.1 PROPOSITION 1: DETERMINING IMPROVEMENTS OF NON-MOTORISED TRANSPORT FACILITIES**

The first proposition focuses on the improvements regarding NMT facilities in Cape Town. Both the quality and quantity of NMT facilities is considered in the research conducted. Cape Town was investigated as it is one of the largest South African cities. Using Cape Town as a case study area, the number of recent NMT facilities and implementations were investigated, as well as the quality of these NMT projects. Within this part of the investigations the following research questions were asked:

1. Where and what type of NMT facilities and implementations have been rolled out?
2. Are these facilities adequately designed and implemented to serve the safety and usage requirements of the people who use them?
3. Do these NMT facilities take into consideration the unique challenges of South Africa, namely security concerns, aggressive driving styles and speeding?

### **1.3.2 PROPOSITION 2: SAFETY OF NON-MOTORISED TRANSPORT USERS**

The second proposition is concerned with the relationship between the implementation of NMT facilities in urban areas of South Africa and the reduced number of NMT fatalities and injuries as a benefit of these implementations. In this research, ‘safety’ refers to road safety and not security concerns related to criminal activities or actions. To investigate this relationship, various case study areas within Cape Town were selected and the NMT implementations investigated. In order to account for general trends and patterns within Cape Town, a number of control case study areas (where no recorded NMT facility improvements were made) were investigated in the same manner.

1. How were the fatalities and injuries trends in the case study areas different from the control areas?
2. Which case study and control area had the highest initial EAN?
3. Were there any changes in the safety trends pre-, during- or post-NMT facility improvements?

### **1.3.3 PROPOSITION 3: NON-MOTORISED TRANSPORT TRIPS**

The third proposition assumes that better NMT facilities will result in higher levels of NMT trips. Therefore, the following questions were proposed:

1. What changes in the volume of NMT trips in South Africa can be seen between 2003 and 2013?
2. In the case study areas that had NMT facility improvements, has there been a significant increase in the number of NMT trips compared to the NMT trips taken in the control areas of Cape Town?

#### 1.3.4 PROPOSITION 4: QUALITY OF NON-MOTORISED TRANSPORT FACILITIES

The fourth and final proposition refers to the inconsistent quality of the NMT facilities that have been implemented. From this proposition, the following research questions are proposed:

1. Do the facilities show evidence of the principles as described in the NMT Facility Guidelines (NDoT, 2015) for the type of NMT facility implemented?
2. How do these NMT facility implementation upgrades compare to the facilities in the control areas?

In order to adequately address these research questions, the following conceptual framework is used.

### 1.4 SCOPE AND LIMITATIONS

The scope of this research is NMT facilities in urban areas of South Africa. Cape Town is used as a case study South African city. While Cape Town does not express all possible urban South African characteristics, it is one of the main cities in South Africa and has been affected by policies and frameworks that have influenced the other major cities in South Africa. It was, therefore, considered a suitable area to conduct the research in. Due to resource constraints, the investigations could not be extended to other urban areas of South Africa.

Even though literature on some other countries such as The Netherlands, Germany and Colombia were reviewed, primary data for this study focused on South African based research and findings. Policies and other non-infrastructural strategies that aimed to improve NMT trips and NMT safety in South Africa were excluded from the scope of this research. The focus of the research is on the impacts that physical NMT implementations have on NMT trips and NMT safety. Considering that there have also not been any significant changes regarding NMT, as a mode of transport, in national policies in the recent years (Walters, 2008; NDoT, 2008; City of Cape Town, 2014), it was assumed that this can be considered to have been a stable element in the development of NMT, as a mode of transport. The guidelines regarding NMT facilities were included, as they provide the direct basis for NMT facilities in South Africa. The guidelines that were reviewed include the Pedestrian Facility Guidelines (NDoT, 2003), as well as the Final Draft of the National NMT Facility Guidelines (NDoT, 2015).

The main limitations of the quantitative investigations were the type of available data of Cape Town, as well as the time frame that was predetermined. The case study infrastructure assessments had several limitations, mostly regarding the rigour of the investigation. Measures could be added in future to improve the assessments so that the results are more subjective and less open to biases of the researcher or the reviewer. Some of these measures include independent reviewers to assign the ratings of the NMT facility implementations and or interviewing local NMT users in order to determine how the users perceive the NMT network within the area of interest. However, even if these measures were added to improve the rigour of the infrastructure assessments, the results would still be largely subjective. The case study infrastructure assessment results can therefore, only be considered to be a

guide at a high level of what could be potentially lacking or what is potentially successful in the NMT facility implementations. The following section presents a general overview of the contents of this thesis.

## 1.5 THESIS STRUCTURE

This first chapter introduces the research topic and the problems that are investigated. Chapter 2 presents a review of literature on the benefits of NMT, as a mode of transport, to present a foundation of why NMT trips are an important and what the various benefits that could be generated by encouraging these trips. Additionally, the types of NMT facilities that could be implemented are discussed. These are divided into facilities that meet the needs of pedestrians and those NMT facilities that meet the needs of cyclists. To conclude Chapter 2, an international case study of The Netherlands is presented outlining how NMT facilities can have an important role in establishing a successful and efficient NMT culture.

Having explored the fundamentals of NMT, as a mode of transport, Chapter 3, Reflection of South African NMT (as a mode of transport), discusses the current challenges of NMT trips in South Africa and the main strategies that have been adopted in order to face these challenges. Furthermore, Chapter 3 then presents the potential benefits that NMT trips and NMT facilities could have in South Africa. The chapter then concludes with identifying the key approach, which based on the literature, has been most under-developed and has the most potential to address the existing challenges of NMT users in South Africa at the moment.

To understand whether or not the identified key approach really does have the capacity to improve NMT trips in South Africa, propositions are proposed and research questions are developed along with a research method. This is explained fully in Chapter 4, Research Method. The next two chapters present the investigations that conducted, in Chapter 5, Quantitative investigations, and Chapter 6, Case Study Infrastructure Assessments of NMT Facilities. After which, the final conclusions are presented in Chapter 7, along with some recommendations based on the research that was done in this research.

## 2. BENEFITS OF NMT: WHY INVESTIGATE THIS MODE OF TRANSPORT?

NMT trips have many benefits for the individuals who make the trips, as well as for society at large (Heinen *et al.*, 2010). This mode of transport is environmentally sustainable, as it does not rely on fossil fuels and can also be a highly efficient mode of transport (Litman, 2002; Heinen *et al.*, 2010). These characteristics make NMT an attractive mode to encourage and develop, especially as the world looks to move towards less polluting forms of transport. The benefits of NMT trips extend from transportation having reduced harmful environment effects, to improving the health of people.

In Chapter 1, Non-Motorised Transport (NMT) was noted to refer to types of transport that are not powered by engines or motorised vehicles; whilst the term ‘NMT user’ is accepted as an inclusive term that covers road users from pedestrians, cyclists and skaters to individuals that use animal-drawn carts, rickshaws and so forth, to assist their movement (NDoT, 2015). Due to the varied nature of users, there are a number of different types of facilities that are potentially appropriate to or beneficial for the different NMT users. However, for the purposes of this research, the focus will mainly be on facilities for pedestrians and cyclists. These two NMT users (pedestrians and cyclists) are the more standard and most common types of NMT users in both developed and developing countries.

While pedestrians are, generally, the more dominant NMT user type, the cyclists have important advantages in terms of time and energy efficiencies. Therefore, cycling should also be encouraged as a mode of transport. In urban areas of South Africa, where distances between origin and destination of trips are generally longer than in developed countries (Vanderschuren and Galaria, 2003), the advantages of cycling over walking as a mode of transport is important. For the purposes of this research, both pedestrians and cyclists are considered important to discuss and investigate. The various benefits of NMT trips and NMT facilities are now elaborated upon, to establish the potential value of improving NMT facilities in urban areas of South Africa.

### 2.1 BENEFITS OF NON-MOTORISED TRANSPORT AND NON-MOTORISED TRANSPORT FACILITIES

Before the benefits are discussed, the costs of NMT facilities will be discussed as the financial considerations of projects often determine whether the projects are deemed feasible or not. One way of deciding whether investing in NMT facilities is prudent or not, would be to look at some of the cost-benefit analyses that have been done. Generally, cost-benefit analyses of walking and cycling infrastructure indicate that investments in cycling are cost-effective and beneficial (Elvik, 2000; Sælensminde, 2004; Cavill *et al.*, 2008). The potential value of NMT trips (namely, walking and cycling) is not only applicable to developed countries but also for developing countries (Massink *et al.*, 2010; Whitelegg and Williams, 2000), where it is currently often undervalued as a mode of transportation (Massink *et al.*, 2010). While implementing other forms of transportation facilities, such

as highways and railways, may be costly for developing countries, the positive cost-benefit ratios demonstrated by Sælensminde (2004) and other mentioned researchers indicate that these types of investments would generate a high sustainable return (in terms of investments) for the countries that choose to develop their NMT facilities. One of the fundamental principles that these high returns on NMT facilities are based on is the reduction of NMT collisions, while increasing NMT trips. However, if the impact of the South African context has a dominant effect on this fundamental principle, that reduces the benefits of NMT facilities then alternative measures should be investigated. Determining whether the South African context does or does not have a dominant effect on NMT facilities in urban areas of South Africa is one of the major motivating reasons behind this research.

In this chapter the focus is on the benefits of NMT as a mode of transportation. NMT as a mode of transport helps generate a wide range of benefits for both the individual and the society. The main benefit is increased levels of road safety for NMT users as well as motorised transport users. NMT trips also helps to improve health, as well as the environment. As a sustainable mode of transport, it also has equality benefits for communities that increase the levels of NMT trips through improving the efficiency, safety and convenience of NMT trips. By improving the quality of a NMT trip the transportation system becomes more equitable as NMT users trip experiences that are on par with motorised trips. It is important to note that improving NMT facilities is especially important in addressing the needs of the more socio-economically vulnerable members of society that rely on NMT trips to meet their travel demand. A simple example would be providing well maintained sidewalks for school children walking to school, that improves their experience compared to walking to school along an uneven, unattractive road where there is no separation from motorised traffic. The various benefits of NMT, as a mode of transport, will be elaborated upon in the following sections. As the benefits are discussed, the role of NMT facilities have will also be elaborated on, to demonstrate the connections between implementing NMT facilities and the benefits of NMT, as a mode of transport.

### 2.1.1. SAFETY BENEFITS OF NON-MOTORISED TRANSPORT

One of the negative externalities of motorised transportation is the high number of road fatalities and injuries. This is particularly true for developing countries and South Africa is a prime example thereof, as it has one of the worst levels of road safety in the world (Mabunda, *et al.*, 2008). These fatalities and injuries have massive impacts on both those involved in the road collisions, and those who are left behind (Mohan, 2002).

While high road fatalities and injuries are typical of developing countries, they are not inevitable and should be addressed with appropriate and adequate actions. This has been done in several developing countries already. One such country is Colombia, which has managed to improve the levels of safety through various strategies, including the implementation of NMT facilities, NMT events (most notably the Bogotá's Ciclovía), education initiatives, as well as creating awareness regarding NMT, as a mode of transport (Montes *et al.*, 2012; Bogotá Como Vamos, 2014; Gomez *et al.*, 2015). While Colombia still has significantly more to do to improve the level of road safety to more acceptable levels, the

progress so far is encouraging and indicates that prioritising and emphasising NMT, as a mode of transport, has positive impacts on improving road safety numbers.

In Figure 1, the City of Bogotá, Colombia, has shown that increasing levels of cycling correspond to decreasing numbers of fatalities. During the period between 2003 and 2013, an increase in the implementation of bicycle lanes was carried out, which helped to increase the use of bicycles in the city (Verma *et al.*, 2015). The decreasing trend of cyclist fatalities with the increasing number of NMT trips is consistent to the trend found in developed countries, as described by Pucher and Buehler, (2008). Figure 1 indicates that, despite the different context between developing and developed countries, implementing NMT facilities in a developing context also correlates to an increase in the number of NMT trips, which correlates strongly with improved road safety.

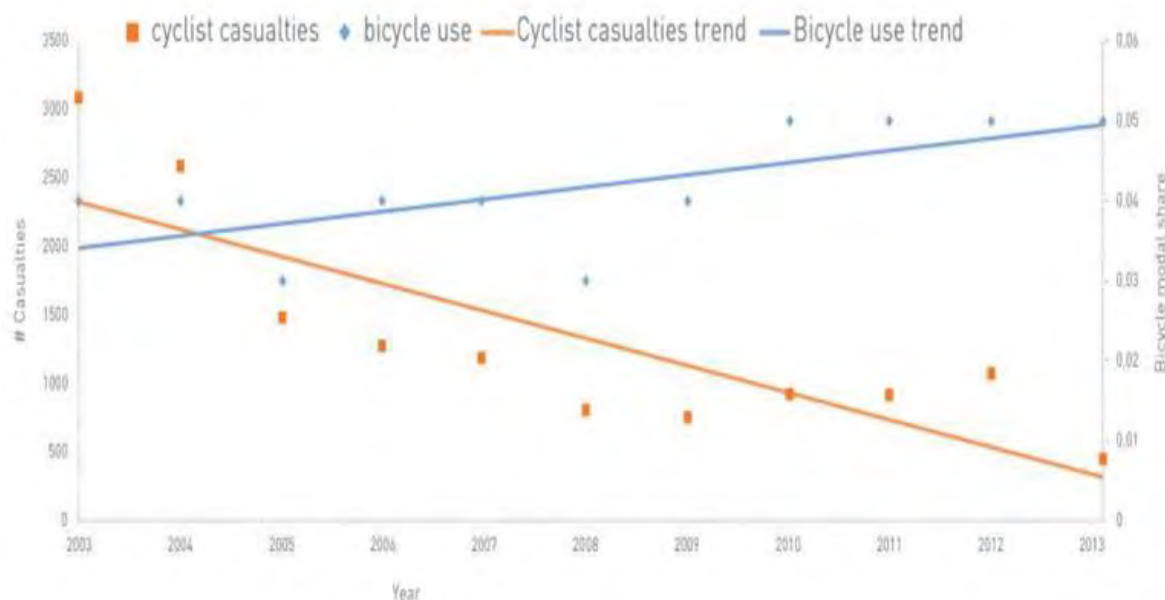


Figure 1: Cyclist Casualties and Bicycle Use in Bogotá, 2003-2013 (Source: Bogotá Como Vamos, 2014 and Secretaría Distrital de Movilidad, 2014a)

Several studies (Jacobsen, 2003; Pucher and Buehler, 2008; Elvik, 2009; Verma *et al.*, 2015) indicate that implementing bicycle infrastructure leads to a significant decrease in fatalities and injuries of vulnerable road users, and to increased rates of walking and cycling. Both developed and developing countries have demonstrated this impact of NMT facilities on fatalities and injuries (Jacobsen, 2003; Elvik, 2009; Verma *et al.*, 2015). As mentioned by Pucher and Bucher (2008) and Jacobsen (2003), the more people who walk or cycle, the less likely a motorist is to collide with them. The relationship between the number of people walking and cycling and the chance that they will be involved in a collision with a motorised vehicle, for developed countries, is predictable and has been modelled by Jacobsen (2003). This is somewhat different to the situation in South Africa where a majority of



people already walk. Cyclists in South Africa are however still a minority road user group, who are especially vulnerable. The philosophy of safety in numbers seems to have more of a critical aspect for these road users, which may explain why officially and unofficially organised cycle tours and races are well supported and relatively common but commuting rides by these same individual riders' remains comparatively low. These middle and higher income cyclists are more likely to use motorised transportation as their selected mode of transportation (Behrens, 2004). South Africans generally see cycling as a form of commuting as an unattractive mode of transportation (Bechstein, 2010). However, cycling and walking, have several attractive benefits, with one of the largest incentive benefits being the associated health benefits.

### 2.1.2. HEALTH BENEFITS OF NON-MOTORISED TRANSPORT

Ensuring that a significant proportion of all trips are NMT trips, has several health benefits (Sælensminde, 2004; Oja *et al.*, 2011; Massink *et al.*, 2011). Health benefits include reducing the risk of premature mortality, certain cancers, high blood pressure, type-2 diabetes and musculoskeletal ailments (Sælensminde, 2004), among other Non-Communicable Diseases (NCD) (Mayosi, *et al.*, 2009). The majority of these benefits are, due to increased physical activity associated with NMT trips (Reynolds, 2009; Mayosi, *et al.*, 2009).

In many developing countries, such as Colombia, the value NMT trips due to the associated health benefits is a driving motivation behind many of the recent policy and urban environment changes that have occurred in recent years (Parra *et al.*, 2007). In Bogotá, Colombia, several changes have been made to increase the amount of NMT trips that are made and in so doing, increases the level of physical activity of the people of the city. Several projects, facilities and events have been implemented to encourage people to include walking and cycling trips in their daily lives. One of measures include “The Cicoloruta Transportation System” which is a network of 300km of dedicated bicycle paths (Parra *et al.*, 2007). The initial motivation for implementing the Cicoloruta was to help reduce the congestion in the city (Parra *et al.*, 2007; Massink *et al.*, 2011) but it is now seen as an important component of encouraging a healthy life-style for the inhabitants of the city.

Recently, the severity of South Africa's obesity has been in the focus of the media. It was recently found that more individuals in South Africa are likely to die from obesity related illnesses than poverty related illness (Health Systems Trust, 2015). The government is now taking significant steps towards in order to addresses this specific health burden of South Africa (South Africa Government, 2015). Increasing NMT trips (commuting or recreational) will help to address this specific and growing health challenge. Furthermore, with the increasing focus on environmental concerns, NMT trips are also seen as a possible way of improving the quality of the environment by reducing carbon emissions (Massink *et al.*, 2011), air pollution and other negative impacts (Jacobsen, 2003) associated with urban settlements.



### 2.1.3. ENVIRONMENTAL AND SUSTAINABILITY BENEFITS OF NON-MOTORISED TRANSPORT

One of the most important benefits of increasing NMT trips are the positive effect it has on improving the urban environment by reducing levels of pollution and congestion. This is especially true and applicable for the developing world (Whitelegg and Williams, 2000; Massink *et al.*, 2010). The rapidly increasing transport demands, especially of developing countries, would not be as problematic if it were not for the various negative externalities that appear in various costs and damages. However, as the trend in developing countries is to shift towards higher dependency on motorised transportation, the transport demand and trends needs to be consciously managed, if these negative externalities are to be avoided.

In developing countries such as Colombia and Mexico, this benefit of NMT trips have become important way for ensuring the liveability in urban spaces. Liveability, as a concept, is often considered to be defined as taking into account a wide range of factors that affect the quality of life for people in an area. Howley *et al.* (2009) defined liveability to include factors may include levels of health, sense of safety, access to services, cost of living, mobility and accessibility and social interactions. Improving liveability, ultimately, results in spaces that are sustainable, productive, cost efficient, as well as attractive to live and work in.

It has become an essential concept due to rapid urbanisation and increasing population growth in urban spaces. As the demand for resources and services grows in urban areas, including escalating transport demands (Massink *et al.*, 2010; Verma *et al.*, 2015), managing the sustainability and liveability of settlements becomes increasingly important. For example, transport demands are often met by motorised transport modes, which generates more negative externalities for the environment, as well as the health of people (Jacobsen, 2003; Wright and Montezuma 2004; Massink *et al.*, 2010). NMT trips help to reduce the demand for motorised transportation by providing an alternative that is cheaper than motorised trips and, generally, more efficient in terms of resources used and energy required. Thus, by prioritising NMT, as a mode of transport, the liveability of an area can be improved upon, by reducing and mitigating the various negative externalities of motorised transportation. For example, in Bogotá, where recent prioritisation of increasing the number of NMT trips and improving public spaces has occurred, a reduction in emission from motorised transport has been recorded by the air quality monitoring systems of the city. The reduction of emissions was attributed to the increase in the proportion of walking and cycling trips, which has been estimated to be responsible for as much as 40% of the reduction of some of the pollutants (Wright and Montezuma 2004). NMT trips have made a significant contribution to addressing the severe air pollution challenge and is of great value for the city of Bogotá.

Massink *et al.* (2010), do indicate that Bogotá's bicycle modal share is still relatively small compared to other developed countries, such as The Netherlands, the benefits are still substantial (Massink *et al.*, 2010; Montes *et al.*, 2012; Gomez *et al.*, 2015). Massink *et al.* (2010) were also able to show that these

benefits of CO<sub>2</sub> saved would be valued at between \$1 million and \$7 million, depending on various influencing factors, while Montes *et al.*, (2012) showed the high benefit-to-cost ratios of pro-NMT programs.

NMT trips, therefore, help to decrease the negative externalities of motorised transport trips. As alluded to earlier, these negative externalities of motorised transportation include high levels of emissions (most notably Green House Gasses), noise pollution, reduced road safety, increased levels of congestion, and the associated loss of productivity thereof (Massink *et al.*, 2010). Furthermore, NMT trips have been noted to address the equality challenges that surround transportation, which will now be elaborated upon.

#### 2.1.4. EQUALITY AND SOCIO-ECONOMIC BENEFITS OF NON-MOTORISED TRANSPORT

The role that transportation has in addressing equality challenges, such as social exclusion, has been well established and noted in various studies and policies (Litman, 2002; Behrens, 2004; City of Cape Town, 2005; Gray, *et al.*, 2006; Garrard, *et al.*, 2008; UNEP, 2010; Van Wee, 2011). This section presents a brief summary of transportation equality concepts and challenges. In addition, the role that NMT trips and NMT facilities have in addressing these challenges is highlighted.

There are several types of equity within a society (Litman, 2002), which can be described in terms of:

- 1) Horizontal equity (*fairness*): equal treatment of equals;
- 2) Vertical equity (*social justice between different groups of individuals*): with respect to income and social class;
- 3) Vertical equity (*social inclusion of all abilities*): with respect to need and ability (Litman, 2002).

These three types of equity will now be discussed briefly in the context of the role that NMT, as a mode of transport can have for South Africa. Firstly, horizontal equity, also referred to as *fairness*, deals with the distribution of impacts between individuals and groups (Litman, 2002). With this in mind, resources and costs should be equally and fairly distributed, without one group of individuals experiencing more favour than another. Fair allocation of resources and costs would help to reduce the chance of social exclusion. Van Wee (2011), defines social exclusion as ‘*the fact that some people or population groups are excluded from a certain minimum level of participation in location based activities, whereas they wish to participate, and need to do so in order to maintain a reasonable quality of life within the society in which they live*’. An example to explain this type of equity can be seen clearly between the different types of transport modes. In South Africa, motorised transportation has been prioritised over NMT, as a mode of transport, in terms of infrastructure, priority of road space and safety. Therefore, NMT users are often viewed as being second class road users, where an increase in horizontal equity would result in them having the same level of experience and same level of service as a motorised transport user.

Transportation within a city has significant roles in either reducing the levels of inequality by providing affordable and accessible modes of transportation for all socio-economic groups, or by reinforcing inequality by investing more resources in modes of transportation that promote social division (Van Wee, 2011). This is an important consideration as higher income earners often have more resources to effectively dominate road space, whether intentionally or unintentionally. Prioritising private motorised transportation over PT and NMT is a classic example of an inequitable decision.

The impacts of these inequitable transportation decisions are significant and wide-spread. Litman (2002) highlights a few of the consequences of inequitable transport decisions. One of these consequences are the additional direct and indirect costs for socio-economically vulnerable individuals, including increased amount of time spent commuting, increased exposure to pollution, increased risk of involvement in road collisions or attack on personal safety. This is an important concern for South Africa which has a young population, high levels of unemployment and low income individuals. Secondly, inequitable transport decisions have a large impact on the type of employment opportunities and the manner that economic developments occur, which can have a significant impact on the opportunities and quality of life for lower-income groups. By implementing NMT facilities that improve the mobility and access of individuals, especially in lower and middle income areas, the South African road infrastructure will meet the needs of more road users than only those that have access to motorised transportation. This leads onto the second type of equity.

Vertical equity, with regard to income and class, is also referred to as *social justice* or *social inclusion* (Litman, 2002). In this type of equity the focus is on the deliberate redistribution of resources to address the socio-economic inequalities that current exist. This often results in an emphasis being placed on vulnerable road users or vulnerable socio-economic groups challenges and needs over the needs of more privileged groups. Transport policies, strategies and implementations should be adjusted to compensate for economically and socially disadvantaged groups. One clear way that this could be achieved, would to increase the priority of NMT as a mode of transport in its own right, as well as a feeder mode to other forms of public transportation. Improving the quality and efficiency of NMT as a mode of transport, not only addresses the transport needs of vulnerable groups of society, but also helps to improve the status and culture acceptance of NMT trips. In turn, the investments in the NMT facilities help to reduce the social and economic stigma attached to walking and cycling.

The third type of equity deals with the various mobility needs of travellers with any form of mobility impairment (Litman, 2002). In practice this implies that transport facilities and services should take into account the various needs of the different levels of mobility of different types of users. Addressing the needs of all types of user links directly to improving social exclusion and has strong connections to both levels of access and accessibility. Access is defined from an individual's perspective and accessibility is defined from a location's perspective (Van Wee, 2011). The level of accessibility that a socially excluded individual may experience can also be described as the mutual interactions between the transport system, the land-use system, the individual component and the time component. In South

Africa, where a large proportion of the population is very young, accommodating the movements of children is important in ensuring that they are able to move around their environments safely and without being physically or mentally strained or harmed. This is an essential in accommodating these vulnerable road users (Vanderschuren, Baufeldt, and Phayane, 2015). This is especially applicable for walking trips of children and scholars.

Additionally, ensuring that all individuals with any type of mobility impairment are taken into account is necessary to create a transportation system, and therefore a society, that is equitable and inclusive. Implementing NMT facilities that accommodate all levels of walking and cycling abilities is a way of bettering the levels of equality. NMT facilities and implementations can have a considerable role in improving the safety and efficiency of NMT trips. NMT trips can directly help address some of the consequences of an inequitable transportation system. The transportation system of South Africa is particularly inequitable (Vanderschuren and Galaria, 2003; Behrens, 2004) and therefore this impact of NMT, as a mode of transport, would be especially valuable. By providing NMT facilities and allocating sufficient road space to NMT users, the transportation network becomes more equitable between the different road users. Consequentially, NMT trips aid in increasing the accessibility and mobility of socio-economically sensitive individuals to employment opportunities and economic developments.

In the following section the design details of the various NMT facility designs and implementations in a number of countries, both developing and developed, will be briefly reviewed. The design details cannot be completely separated from contextual aspects that often influence the success of the actual NMT facilities that are implemented. In order to present a complete view of how NMT facilities influence the urban environment, these external elements and aspects will also be discussed. Therefore, concepts such as connectivity, walkability, network design and land-use are explored as necessary alongside the design principles and guidelines regarding NMT facilities. In the following section the various NMT facilities are described and the design principles that ensure that the facilities add value to the built environment are summarized.

## 2.2 NON-MOTORISED TRANSPORT FACILITIES: TYPES AND DESIGNS

This section aims to review the various designs and implementations that have been developed to improve the level of service for NMT users. The focus will be on facilities for walking and cycling. Before the details of NMT facilities are discussed, it is important to consider the physical environment of the NMT facilities. The success of NMT facilities can be influenced by several environmental aspects, as shown in Figure 2.

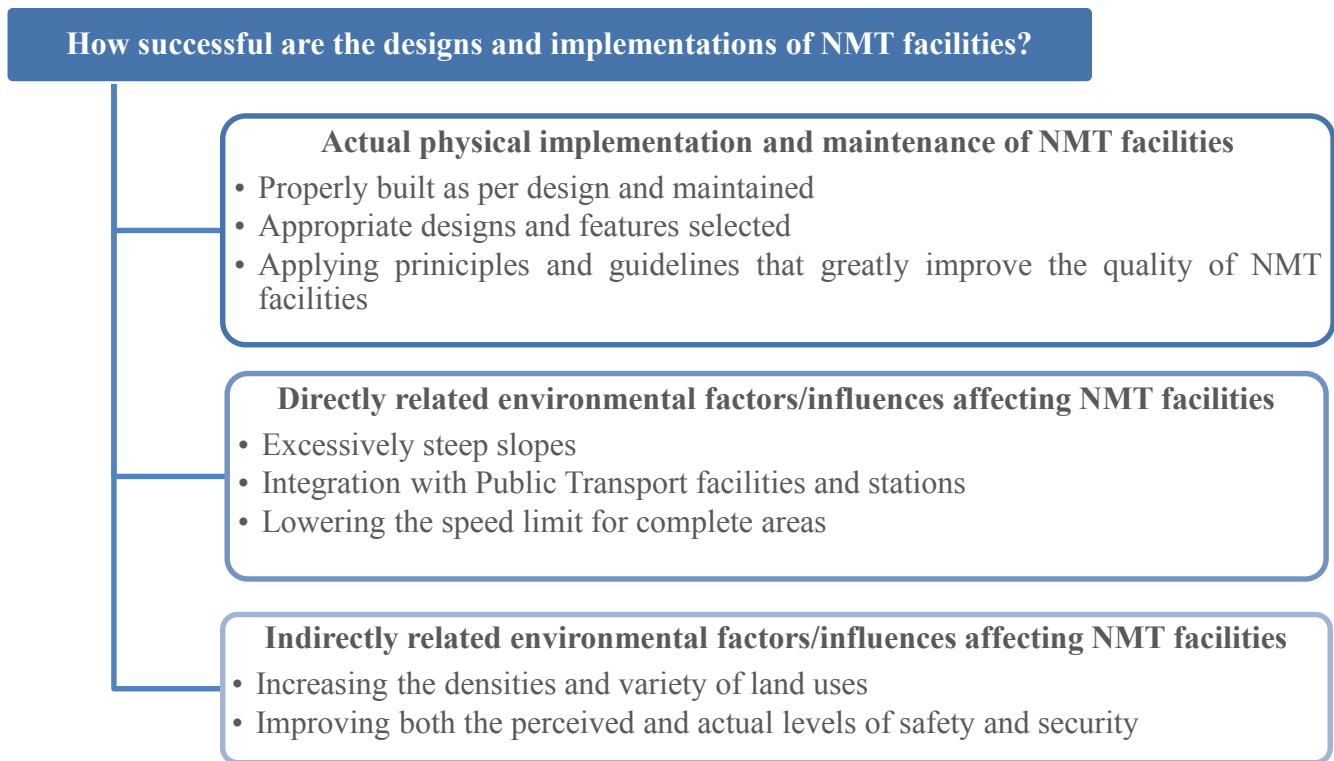


Figure 2: Physical Context of Non-Motorised Transport Facilities<sup>1</sup>

The success or failure of NMT facilities can be affected by a variety of influences and factors. Some of the influences that can increase the levels of success of NMT facilities are area-wide implementations that increase the quality of a facility. Implementations can include a range of approaches, such as lowering the speed limits of motorised traffic, increasing densities of urban areas and the variety of land use types, and improving the levels of security through increased levels of policing and surveillance cameras.

However, the above mentioned factors and influences are outside the scope of this research. Attempting to include these aspects in the research would not be practically possible or feasible. However, identifying and acknowledging that they do have an impact on the success or failure of NMT as a mode of transport, will help to prevent misinterpretation of case studies, especially in areas that have had any significant changes that may have arisen from external influences and factors, in conjunction with a change in NMT facilities.

The focus is to describe possible NMT facilities based on the best practices from around the world. While it is not practical to cover every possible design or concept, the fundamental concepts along with a selection of more innovative NMT facilities options will be explored.

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<sup>1</sup> Figure is own work

### 2.2.1 PEDESTRIAN FACILITIES

Pedestrian facilities can vary considerably, from simple cost-effective sidewalks to multi-purpose recreational parks. Often the quality of the journey is as important as the destination for pedestrians, as they interact closely with the surrounding environment. Pedestrian facilities often serve several functions. Parks, for example, can either be the destination of a recreational trip or can form an attractive link as part of a NMT route.

In the example of a park, both suggested functions rely on the pedestrian facilities linking the origin of the individual with the park and also to the surrounding areas of the park, especially if the pedestrian is using the park as part of their trip. Therefore, the concept of creating an integrated pedestrian network is important (DTTS, 2013). The pedestrian networks can be broken down into components of crossing facilities, link facilities and amenities. The different components of a pedestrian network are now discussed in the following sections, starting with crossing facilities.

#### 2.2.1.1 PEDESTRIAN CROSSING FACILITIES

Crossing facilities can be considered to be one of the most critical types of facilities, as this is often the most dangerous part of the journey for pedestrians (Vanderschuren and Galaria, 2003; Behrens, 2005). Careful consideration of the location and the design of the crossing facility are important to best meet the needs of those pedestrians for that particular context and urban environment.

Within this section, the general concepts regarding crossing facilities will be discussed first, and then the more detailed aspects and designs will follow. The first general consideration is the different needs and capabilities of different users that need to be taken into account when considering what and how a pedestrian crossing facility is designed and implemented. Several types of pedestrians need to be considered and will influence the design and implementation. Some examples of types of pedestrians that could influence the design and implementation of crossing facilities include:

- Children (those that require the assistance of an adult)
- Older children or young adults (those that may engage in risky behaviour),
- Older adults,
- Individuals using mobility aids (for example, crutches and wheel-chairs), as well as,
- Individuals with permanent or temporarily impaired levels of mobility. This could include individuals with disabilities, adults accompanying small children, pregnant women and individuals carrying loads.

Considering the needs of different pedestrians will result in better designs and implementations for all users. By taking into account the various needs of different individuals, the resulting facilities would contribute to creating environments that are socially inclusive and safe for all members of society to use (Audirac, 2008; DTTS, 2013). In the NMT Facility Guidelines (NDoT, 2015), some of these users



have been noted and various space requirements and dimensions have been suggested. The suggested dimensions for these users are presented in Figure 3 and Figure 4.



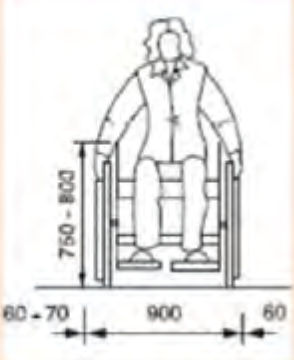
Basic dimensions of people and equipment	Example
Minimum passage width – stick user	<div data-bbox="602 447 708 478" data-label="Text">750 mm</div> <div data-bbox="867 447 1094 810" data-label="Image">  </div>
Minimum passage width – double crutch user	<div data-bbox="602 852 708 884" data-label="Text">900 mm</div> <div data-bbox="867 852 1159 1272" data-label="Image">  </div>
Minimum passage width – adult and child	<div data-bbox="602 1314 724 1346" data-label="Text">1100 mm</div>
Minimum passage width – wheelchair	<div data-bbox="602 1430 708 1461" data-label="Text">900 mm</div> <div data-bbox="867 1430 1159 1787" data-label="Image">  </div>

Figure 3: Part 1 of Requirements for Non-Motorised Transport Users with Special Needs (Source: NMT Facility Guidelines UK Department of Transport, 2002)



Basic dimensions of people and equipment		Example
Length of space for wheelchair and user – conventional seating	1250 mm	
Length of space for wheelchair and user – legs outstretched	1500 mm	
Length of space for wheelchair and assistant	1750 mm	
Length of space for adult and assistance dog	1500 mm	
Length of powered scooter / electric pavement vehicle	1500 mm	
Manoeuvring space for wheelchair at 90 degree turn	1500 mm x 1500 mm	
Manoeuvring space for wheelchair at 180 degree turn	1600 mm x 2000 mm	

Figure 4: Part 2 of Requirements for Non-Motorised Transport Users with Special Needs (Source: UK Department of Transport, 2002)

Another example, of how a broader consideration will influence the implementation, could be how pedestrian traffic lights or robots are incorporated into crossing facilities. The allocated times set aside for the pedestrians to cross should allow for slower moving pedestrians to cross safely without stress or anxiety. This inclusive approach is aligned with the principles of Universal Access (UA) or



Universal Design (UD) (Audirac, 2008). Some of the common elements in a crossing facility that conform to UD principles include the following:

- Drop kerbs that are flush with the road/crossing facilities,
- Slopes of not more than 1:12 gradients, or an alternative route/solution,
- Removal of obstacles (including poorly placed street furniture),
- Appropriate surfacing, and
- Clear markings indicating crossing facilities, as well as appropriate information regarding the surrounding areas.

On a more detailed level, there are various aspects of pedestrian crossing facilities that should be considered. In areas with a large volumes of pedestrians or areas that have high peak volumes of pedestrians, determining the actual and future demand of pedestrians is important to ensure safety and comfort. When considering large volumes of pedestrians at a certain time, the available waiting space at a crossing facility is important to ensure that the individual can be comfortable and safe until it is possible to cross. It is, once again, important to maintain a comprehensive approach and include the needs of individuals using wheel-chairs or prams, or carrying loads or parcels, into the various components of a facility.

For road facilities, that are considered ‘wide’ for a pedestrian to cross, providing refuge islands (also called pedestrian islands) is one way of reducing the challenge and improving the safety of pedestrians. When considering the details of a crossing facility design, the crossing facility and the movement patterns of individuals should be taken into account and aligned with each other. This will generate a crossing facility that is self-regulating, while providing a standardized type of facility that motorised and other NMT modes of transport can interface with. In the NMT Facility Guidelines (NDoT, 2015), a suggested design for a Midblock Crossing Facility illustrates how a refuge island can assist pedestrians in crossing a wide road. This is shown in Figure 5.

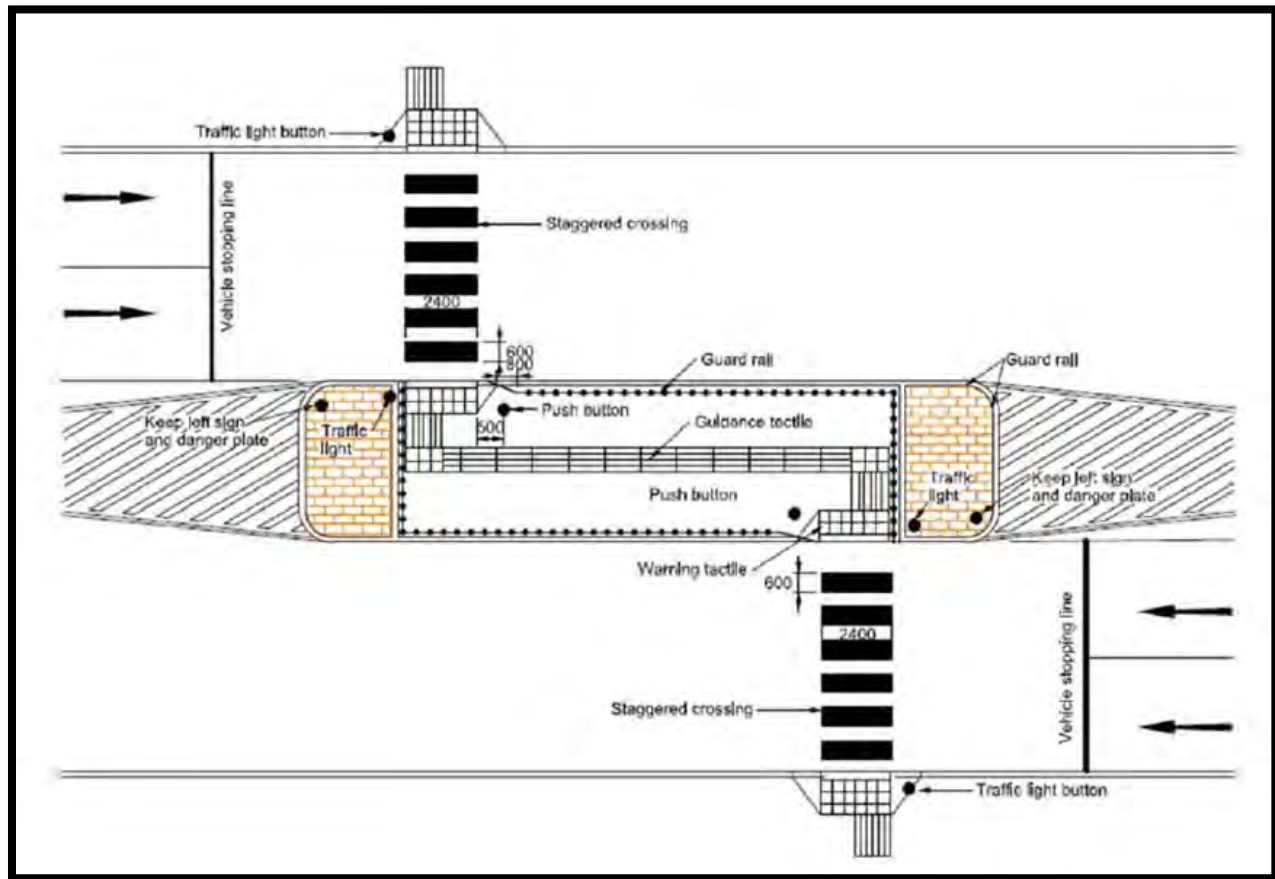


Figure 5: Pedestrian Midblock Controlled Crossing Facility (Source: Gibb, 2010; NDoT, 2015)

Whenever there is an interface between different modes of transport, especially between motorised and non-motorised, it is important to ensure that there are appropriate lines-of-sight for both for the NMT user and the motorised traffic. This can be approached in several ways; however in principle two main approaches are used at intersections. On the one hand, the radii of the pavements can purposely be made small, which forces the drivers to slow down to navigate tight corners. On the other hand, the radii can be designed to be large, which increases the number of desire lines for the pedestrians, as well as improving the sight distances for both pedestrians and drivers. These two different approaches are illustrated in Figure 6 and Figure 7.



Figure 6: Smaller Radii; Desire Lines and Sight Distances (Source: NDoT, 2015)

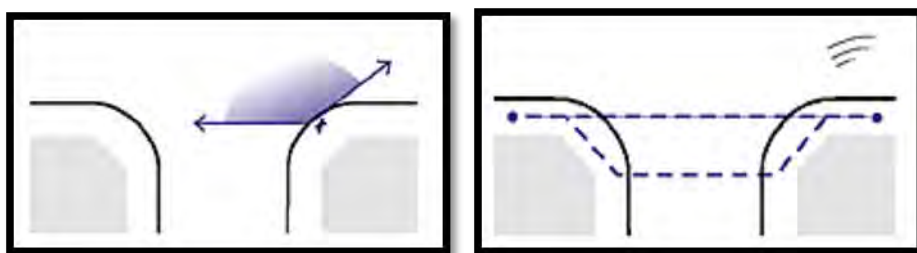


Figure 7: Large Radii; Desire Lines and Sight Distances (Source: NDoT, 2015)

The more detailed concepts and design options will now be elaborated on in the following sections. These are divided into crossing facilities that are at-grade, elevated or sub-grade. Within each of these sections, three examples are presented and their basic principles are outlined.

#### 2.2.1.1.1 AT GRADE CROSSING FACILITIES

At grade crossing facilities are generally more cost effective and easier to be aligned with the principles of UA than elevated or sub-terrain crossing facilities. In principle, the advantage of at grade crossings is that differences in height do not need to be overcome by either motorists or more importantly by NMT users, which are the more sensitive road users to changes in elevation. These two factors may be main reasons why at-grade crossing facilities tend to be the most common type of pedestrian crossing facilities. Over the years, many variations of traditional at grade crossing design have been developed and implemented.

However, the main tradition crossing variations of mid-block (i.e. crossing not at intersections) include:

- Zebra Pedestrian Crossing
- Puffin (Pedestrian User-Friendly Intelligent Crossing)
- Pedestrian Prioritised Crossings

The three types of pedestrian crossings will now be discussed in some detail, with the key points of each design being the focus of the discussion. The first design that will be discussed is the Zebra

**Pedestrian Crossing.** This is probably one of the most conventional and common types of pedestrian crossing designs. It is demarcated by alternating rectangular strips of white and black, and gives priority to pedestrians. Variations of this facility include raising the pedestrian crossing facility so that motorised traffic has to slow down to move over the raised level of the crossing regardless if there are pedestrians or not. This helps drivers remain alert and drive at lower speeds in the area surrounding the crossing facility. Other variations of implementing zebra crossings include installing traffic calming devices such as chokers or rumble strips before the pedestrian crossing. However, care should be taken not to use speed-humps and other devices that have been shown to be inefficient and costly (Pau, 2002).

The second crossing facility is called Puffin, which stands for **P**edestrian **U**ser-**F**riendly **I**ntelligent Crossing design. In this particular design of a crossing facility, various aspects of UD can be demonstrated. An example of a Puffin Crossing design can be seen in Figure 8.

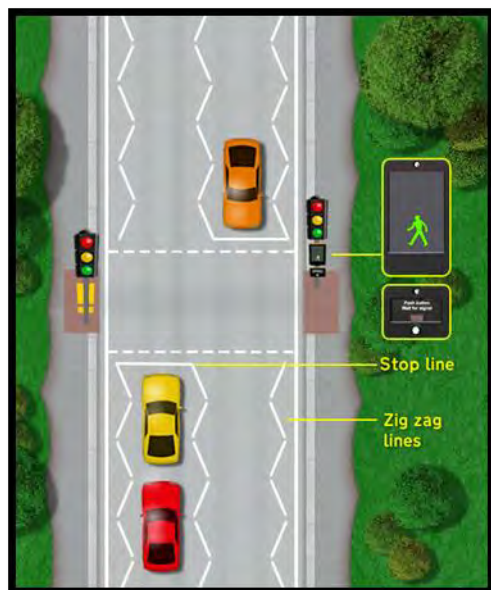


Figure 8: Example of a Pedestrian User-Friendly Intelligent Crossing design (URL: <http://www.drivingtesttips.biz/puffin-crossing.html>)

Firstly, as with the zebra crossing, the crossing space for pedestrians is clearly marked with painted lines or with a change in paving material. Secondly, the lights that indicate to the pedestrians when it is safe or not safe to cross are positioned on the same side of the street as the pedestrian. This helps those that are visually challenged to know when it is safe to cross. Thirdly, the amount of time that is allowed for the crossing pedestrians varies according to the speed of the pedestrians on the crossing, with slower pedestrians being allowed the maximum green pedestrian time. Pedestrians that cross quickly will reduce the green pedestrian time, therefore reducing excessive waiting for the motorised traffic. The design has also removed the flashing amber or flashing green pedestrian indicator to help

remove any ambiguity for both the pedestrians as well as the motorised drivers. In these ways, the crossing facility design has been optimised to be both safe and efficient for both pedestrians and motorised traffic.

The third type of pedestrian crossing is when the movement of pedestrians is permanently prioritised over the movement of other forms of transport. The facilities are either known as a prioritised pedestrian crossings or a pedestrianized streets. Motorised traffic is either completely restricted or has to yield to the flow of pedestrians, until it is clear and safe for the motorised traffic to cross the pedestrian street. The facilities are commonly demarcated by highly visible and prominent signs, as well as the use of different surfacing materials or surfacing colours. One such example of a pedestrianized street / crossing is St. George's Mall in Cape Town shown in Figure 9.



Figure 9: Example of Pedestrianised Street (URL: <http://www.expatcapetown.com/cape-town-fanwalk.html>)

Finally, one design of a crossing facility at an intersection, which can be seen in Figure 10, will be used to discuss and illustrate important concepts and key elements of a crossing facility at intersections, at grade for pedestrians. The first thing to take note of is that the design incorporates traffic lights to completely control the flow of traffic. While this provides clear indications of who is allowed to cross when, it does increase the cost of the intersection significantly but it also helps to improve the equality of the transportation network by providing the necessary facilities for NMT users to cross in a comfortable, convenient and safe manner. Ensuring that pedestrians do not have to wait excessively, before they are given priority at the intersection, is important to ensure that pedestrians are not unfairly hindered by motorised transport, as well as encouraging pedestrians to adhere to the rules of the road and not cross at illegal and dangerous times.

The second aspect of this design is the clear demarcation of the space that pedestrians can use while they wait to cross the intersection and when they do cross the intersections. This is important

especially for people with visual challenges. Another user group that benefits from clear demarcation are young children, for example, who use the lines on the road as an indication of where they are “allowed” or not “allowed” to cross. Consistency in designs help to instil good road behaviour at a young age.

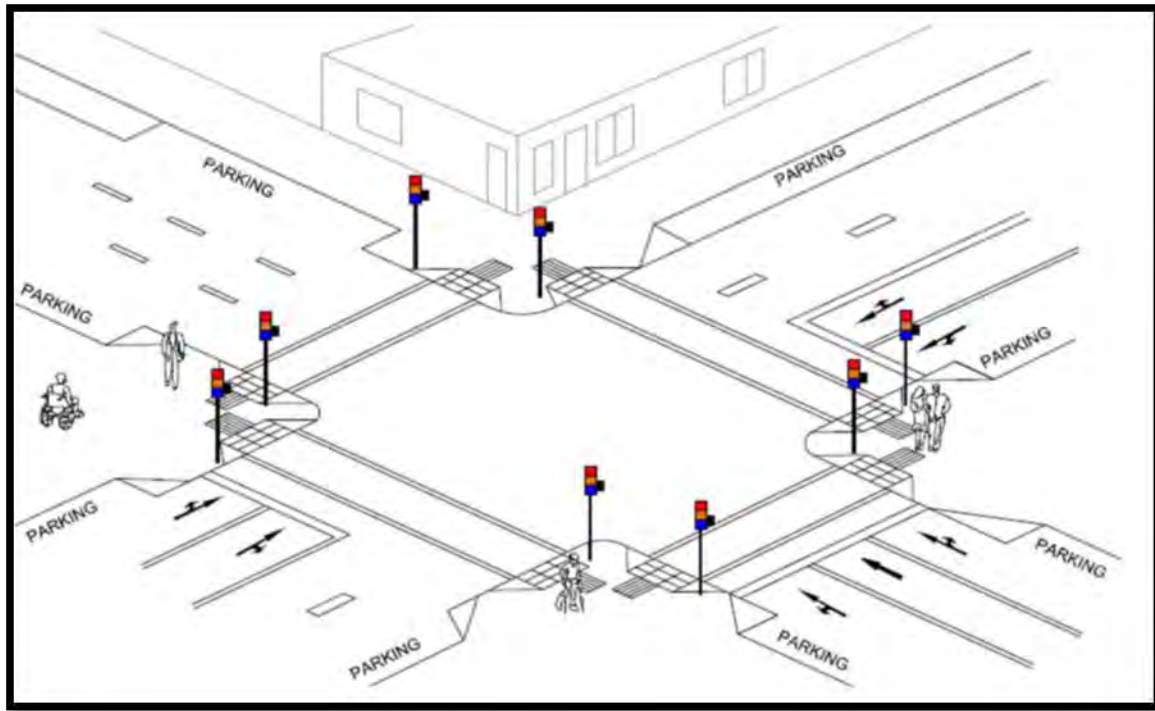


Figure 10: Pedestrian Facilities for Controlled Intersections (Source: GIBB, 2010; NDoT, 2015)

Another concept that can be seen in this design is the use of on-street parking to create a buffer zone between moving vehicles and pedestrians. This acts as a traffic calming measure as drivers become more vigilant of people parking cars, entering and exiting their vehicles, as well as then reduce road space for moving vehicles. Other features that have been included in the design that can improve the intersection as a whole include:

- One directional traffic flows,
- Stopping lines for vehicles have been set back, while pedestrian spaces are forward,
- Drop kerbs linking pedestrian spaces or sidewalks to crossing areas crossing motorised lanes, and
- Tactile pavers.



While the design is only one potential example, many of the principles and features of this intersection are used in several other intersection designs. In the next section, principles and aspects of elevated crossing facilities are explored and summarised.

#### **2.2.1.1.2 ELEVATED CROSSING FACILITIES**

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Elevated crossing facilities are generally used when there is a significant speed difference between pedestrians and the motorised traffic or where the environment is dangerous to install crossing facilities at grade. Elevated crossings for pedestrians most commonly take on the form of different variations of pedestrian bridges, depending on the environment, the allocated resources as well as the users in that are expected to use the facility.

Pedestrian bridges aim to create a completely separated facility that allows pedestrians to cross motorised forms of traffic. Fundamentally though, there is always the challenge of ensuring that there is sufficient clearance for the motorised vehicles under the bridge, while also ensuring that the physical effort and time taken to use the elevated crossing is minimised to ensure that the facility is attractive to users. For individuals with mobility challenges, these elevated crossing facilities are often not accessible due to steep steps, increased routes or slopes that are dangerous to navigate.

An alternative to providing ramps or stairs as access elements to the span of the pedestrian bridge is to provide elevators on either side of the bridge. This solution is becoming increasingly common in areas of the world that have a growing number of people that have mobility challenges. Most notably, in countries with an ageing population and steep terrain, elevators are now providing improved accessibility for people who would otherwise be limited in their daily lives. However, the costs and maintenance of these facilities need to be carefully considered and planned for, as the costs can become a significant proportion of a municipality's budget.

Other facilities that are used to overcome the challenge of different heights are cable cars. While cable cars also tend to be used sparsely, with users normally paying a significant fee to use the facilities, there are cases where cable cars are subsidised significantly as a measure to improve the equality of transport in an area or for an identified vulnerable population group. An example of such an implementation can be seen in Medellin, Colombia (Brand and Davila, 2011) shown in Figure 11.



Figure 11: Cable-Cars of Line K (Source: Brand and Davila, 2011)

Even though the system is expensive and requires significant levels of maintenance, these implementations have done significant good in improving the accessibility of the communities it serves, as well as creating a sense of inclusion and having enormous symbolic significance for the citizens (Brand and Davila, 2011).

#### **2.2.1.1.3 SUB-TERRAIN CROSSING FACILITIES**

Sub-terrain crossing facilities are another way in which pedestrians can be accommodated by providing walking facilities that are either partially or fully separated from motorised transport. Subways, tunnels and underpasses are some of the terms that are used to describe these types of facilities. These terms can be used inter-changeably.

In Figure 12, a typical design for an underpass is shown. In the NMT Facility Guidelines (NDoT, 2015) some of the guiding principles that are given include grade separation, good sight vision, as well as ensuring sufficient width for all possible users.



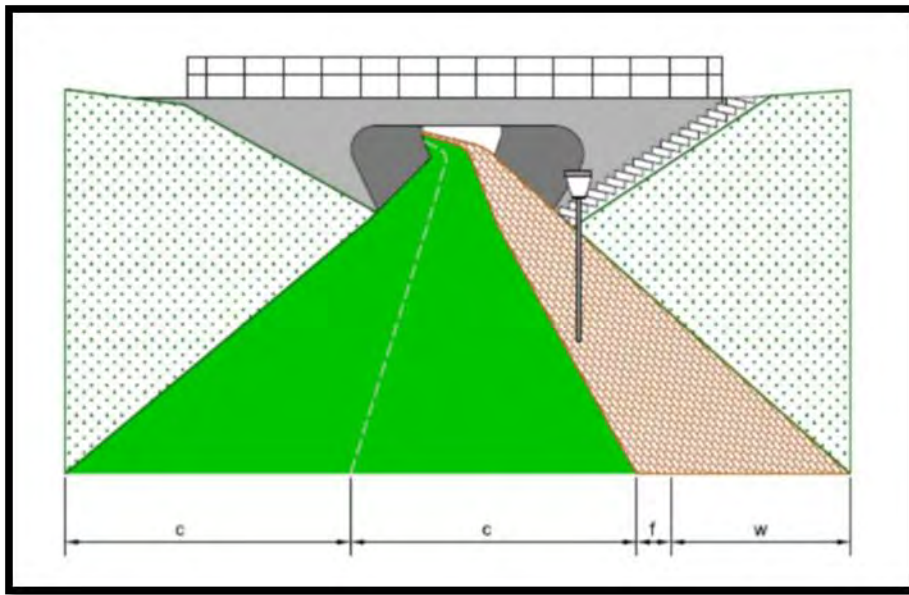


Figure 12: Underpass Design (Source: NDoT, 2015)

These facilities should be designed, implemented and maintained with care though, as they are susceptible to criminal activities, especially if visibility through and around the facility is poor. This often results in these relatively expensive facilities not being used at all or being avoided due to the negative safety perceptions surrounding these facilities. This is especially true in urban areas of South Africa, where many poorly designed subways and other type of underpasses now have warning signs regarding the high risk of crime using these facilities, as shown in Figure 13. This is counter-productive in terms of servicing the NMT users that rely on these facilities to safely overcome physical and motorised transport barriers.



Figure 13: Example of Warning Sign of Security Risk of using Pedestrian Facility, Claremont Railway Station, South Africa (own picture)

### 2.2.1.2 PEDESTRIAN LINK FACILITIES

While crossing facilities are important in ensuring that individuals are able to safely cross traffic barriers, the provision of pedestrian links is critical for ensuring that pedestrians can move in a comfortable, convenient and safe manner. Any link (either a path or a lane) that fails to meet the minimum needs of the pedestrian is likely to prevent or discourage the individual from making the trip in the first place. These sub-quality sections of facilities are often referred to as “missing links” or “broken links” in a pedestrian network. They may be classified as such for various reasons such as low lighting, poor surfacing, inadequate safety or any other hindering factor.

Providing links of a high quality is, therefore, an important component for encouraging pedestrian trips. Considering that the manner in which different pedestrians move along a route is an important part of designing high quality facilities, the different needs of various pedestrians need to be explored, described and suitable designs identified or modified to better serve the range of pedestrians. This will affect many of the design elements of the link facilities, from the minimum required widths, to the type of appropriate surfacing and markings. Taking these different considerations into account will generate pedestrian link facilities that are inclusive and appropriate for a wider range of individuals. Similarly, considering the desire lines of an area will help identify and prioritise the most significant routes taken by pedestrians.

For each link, it is important to consider the context of the link, together with the surrounding urban environment, as well as with the nature of the motorised traffic that is likely to interface with pedestrian movements. Special areas or attractions, such as schools, universities or sporting facilities (especially those that generate high peak volumes), should have special consideration towards the movement of pedestrians and how passengers from motorised vehicles change from vehicles to being a pedestrian safely. The consideration of one-directional traffic, as well as restricted motorised traffic and other measures can be employed to increase the safety of the individuals, as well as the level of comfort and convenience for pedestrians. In this manner, the movement of pedestrians is prioritised over the movement of vehicles, to improve the environment as a whole.

Increasing the physical separation between pedestrians and motorised traffic increases road safety. Another consideration is the security of pedestrians on NMT facilities. Ensuring that the links have passive and active surveillance (in the form of law enforcement agencies or surveillance cameras) can improve both the perceived and actual levels of security for pedestrians moving along these links, especially at off-peak periods.

The final consideration is the balance between providing amenities (benches, water fountains, handrails, dustbins bollards, landscaping) for pedestrians along routes but at the same time ensuring that links do not become cluttered. While amenities can be placed with good intentions, care needs to be taken, as these features can easily impede the movement of the pedestrians if poorly implemented.

### 2.2.1.3 PEDESTRIAN AMENITIES

Pedestrian amenities should be implemented to both assist pedestrians during their trip as well as part of creating a sense of place and belonging. Amenities can range from simple street furniture, such as benches and shelters (especially at public transport stops, such as bus stops), to more innovative concepts such as involving the community in street art projects, and recreational or open spaces where people can interact or relax along their journey. Including elements such as water-fountains, benches, resting areas, along with appropriate information and signage, all contribute to an environment in which the individuals feels at ease and comfortable in their surroundings (NDoT, 2015).

### 2.2.2 CYCLING FACILITIES

The facilities designed and implemented for cyclists often have to balance the need for a smooth comfortable route against providing sufficient separation from either or both motorised traffic and pedestrian traffic. Essentially, in order for a cycling facility to be effective the speed differential between the cyclists and other road users should not be significant if conflicts and dangerous situations are to be avoided.

Well-designed and implemented cycling facilities should create complete routes and networks, which enable cyclists to travel without excessive barriers or hindering elements to their destinations. This not only improves the quality of the journey for the cyclists but also reduces the energy that is needed, as well as the time that is taken on a bicycle. These are key aspects of making cycling as a mode of transport attractive and viable for individuals. As in the previous pedestrian section, the cycling facilities will be discussed in three main sections: crossings; links; and amenities.

#### 2.2.2.1 CYCLING CROSSING FACILITIES

Similarly as with pedestrian crossing facilities, cycling facilities can be either at grade, elevated or sub-terrain. As with pedestrian crossings the balance between safety, overcoming the change in height by the users, as well as potential delays caused by waiting for a clear crossing phase, need to be reviewed in order for the most suitable type of crossing facility to be selected.

Considering that the sustainable approach to transport aims to prioritise NMT modes before motorised modes of transport, crossings that present the least amount of effort to use should be prioritised, even if it is at the expense of the motorised traffic. However, this also has to be balanced against the local context and the safety aspects of the area.

One design that increases the visibility of cyclists to motorised traffic and assists the cyclists to navigate intersections more safely is the concept of a 'Bike Box'. An example is given in Figure 14.

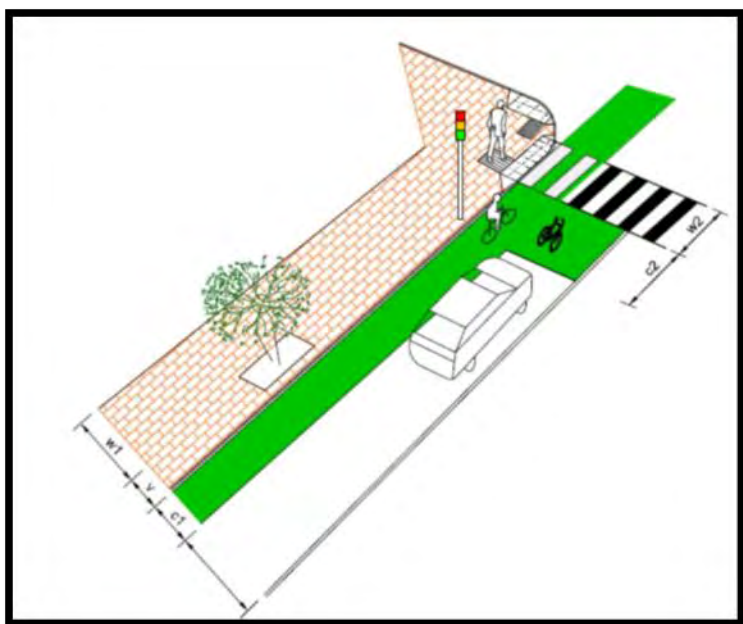


Figure 14: Example of a Bike Box Design (Source: NDoT, 2015)

By encouraging the cyclists to cluster in front of the motorised traffic, they are less likely to be in the blind spot of the drivers. It also allows the cyclists to cross the intersection ahead of motorised traffic which has shown to reduce the conflict between the two types of road users as cyclists are quicker over intersections than motorised transport (NDoT, 2015).

#### 2.2.2.2 CYCLING LINK FACILITIES

While crossing facilities are important for cyclists for the same reasons they are important to pedestrians, link facilities could be argued to have a slightly higher priority for cyclists than they do for pedestrians due to the higher speeds, as well as the time delays should a cyclist experience a puncture or a collision with an obstacle in the link. Ensuring a continuous path that enables cyclists to move more efficiently is an important part of meeting the needs of these NMT users. Therefore, designs such as the one in Figure 15, help to ensure that the movement of cyclists are not unnecessarily compromised by motorised traffic.

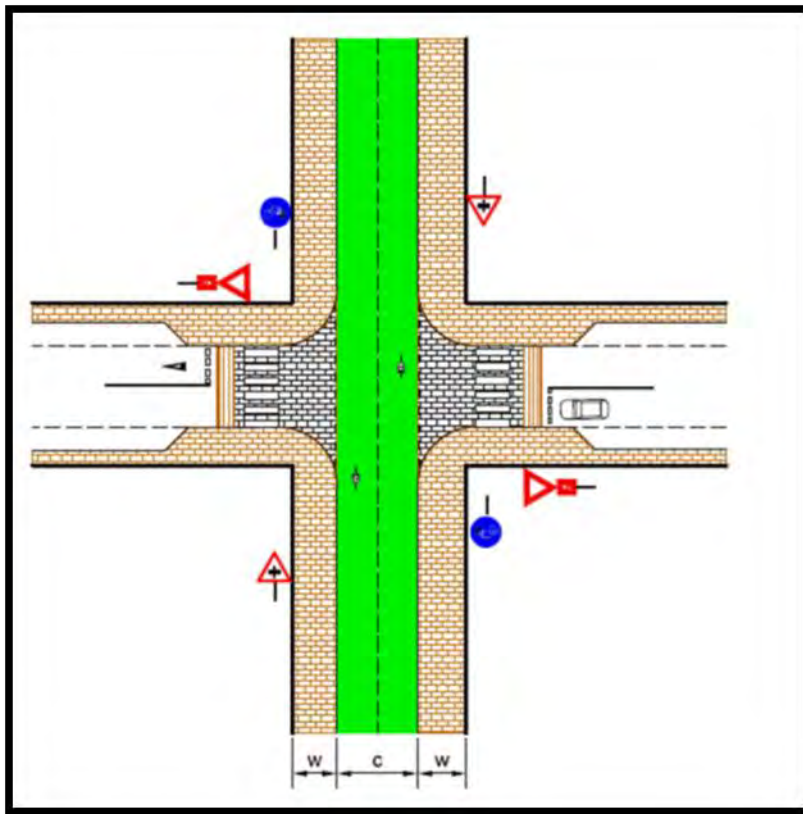


Figure 15: Bicycle Path with Full Priority (Source: NDoT, 2015)

#### 2.2.2.3 CYCLING AMENITIES

As cycling as a mode of transport is often combined with social, recreational and sporting intentions, providing facilities and amenities that enable people to integrate cycling into their working day has many socio-economic benefits, included reduced levels of stress and increased levels of social inclusion. Some suggestions for amenities for cyclists include:

- Drinking fountains,
- Showers and change rooms,
- Toilets,
- Provision of lockers,
- Secure parking of bicycles,
- WiFi hotspots (especially at key locations for tourists as well as locals),
- Bicycle repairs/maintenance services and shops, and
- Sellers of refreshments and light food (normally in the form of coffee shops or local food stalls/ vendors).

For many of the above amenities, a small charge can be placed on using the amenities, in order to cover the expenses of the amenities. However, often, the increased number of cyclists to the areas will result in an increased level of economic activity which often encourages the businesses and service providers to cater for cyclists at no direct additional costs for the cyclists. Having explored the actual potential facilities that could be implemented, the next section moves on to explore how various facilities and processes can result in an environment that is convenient, safe and comfortable to move around in as a pedestrian or as a cyclist.

One country, which is often used as an example where NMT trips have been successfully integrated into daily life is The Netherlands. The Netherlands have actively developed and refined their NMT practices since the 1970's (Pucher and Buehler, 2008) to encourage and establish a culture of NMT trips in their country. Through this process they have found what makes the greatest positive improvements for NMT as a mode of transport and for NMT users. Internationally, The Netherlands is often used as a successful case study of how to increase and establish a sustained NMT culture. Other countries such as the Colombia, France, United Kingdom, and the United States have used the knowledge and the best practices developed in The Netherlands to improve the NMT, as a mode of transport, within their own countries. In the following section, NMT as a mode of transport, in The Netherlands is explored and briefly summarized, thus giving key insights the process of improving NMT as a mode of transport and the established best practices.

## 2.3 A NON-MOTORISED TRANSPORT EXAMPLE: THE NETHERLANDS

Initially, NMT trips (mainly cycling and walking), were prioritised in the Netherlands as a way of addressing the increasing number of fatalities and injuries on roads, as well as easing the rising levels of congestion and the other negative externalities of motorised transport (Pucher and Buehler, 2008; Heinen *et al.*, 2010). Negative externalities refer to the costs that are incurred on individuals or groups that did not choose/agree to the cost that has now occurred for them. This has resulted in NMT trips, more specifically cycling, becoming a significant part of their culture and way of life. While there is still Private Motorised Transport (PMT) (which refers to privately owned cars), many shorter trips are completed on a bicycle, or a combination of NMT trip (walking or cycling) and a public transport (PT) trip (mainly bus or train) (Rietveld, 2001).

Through consistently prioritising road safety and developing its NMT infrastructure, the Netherlands has become one of the safest countries in the world, with regards to transport (Wegman *et al.*, 2007; Pucher and Buehler, 2008). In The Netherlands the main NMT modes are cycling and walking.

The clear impacts that developing NMT facilities had on both the levels of bicycle use, as well as the cycling fatality rates, can be seen in Figure 16. While there are several factors that can influence both 'Bike Use' and 'Cyclist killed', the factors that have been identified to have shaped both curves have been described by Pucher and Bucher (2008) in the following manner:



- 1950s/1960s: Car use dramatically increases. The constrained road space is used by both motorised traffic and cycling traffic
- 1970s: Cyclist fatality rate increases significantly (by 174% from 1950 to 1978), while the amount of cycling falls significantly (65% less for the average km cycled per person)
- Mid 1970s: Massive improvements to cycling infrastructure begin, along with restrictions on car use. It is important to note that there are both 'push' and 'pull' factors implemented
- 1978 to 2006: 81% decrease in cyclist fatality rate with a 36% increase in average km cycle per person.

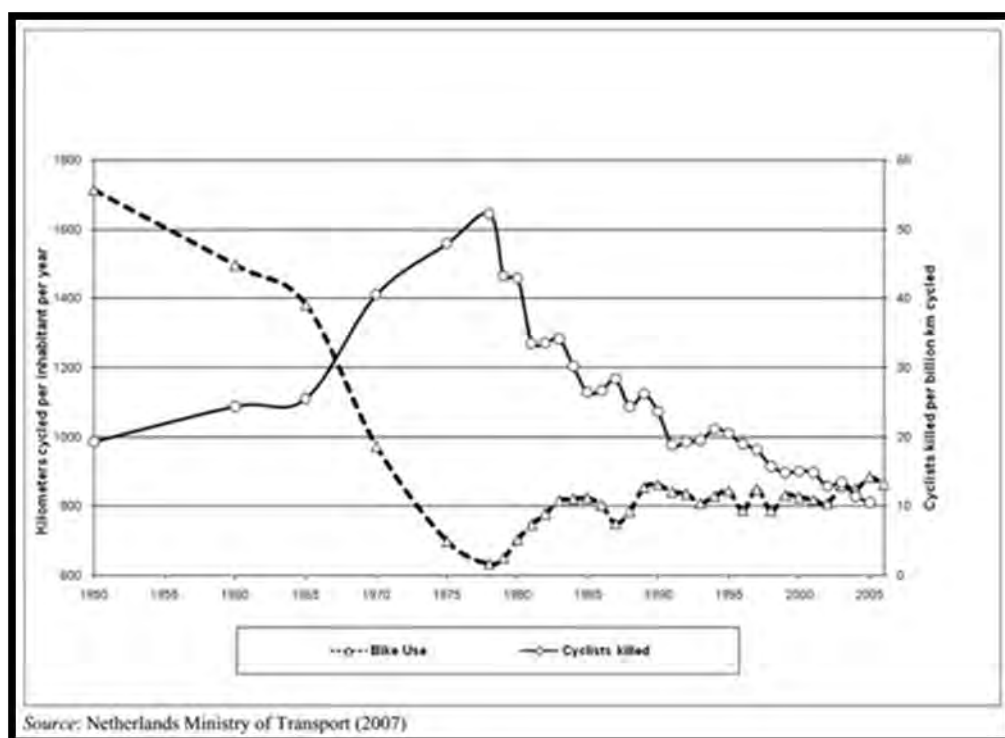


Figure 16: Cycling Fatality Rates and Annual Kilometres Cycled per Person, The Netherlands 1950-2005 (Source: Netherlands Ministry of Transport, 2007)

There is a clear statistically significant positive correlation between the reduction of NMT fatalities and the increase in NMT trips, as seen in Figure 16 (Pucher and Bucher, 2008). Although these data do not prove causation, they nonetheless provide support for the argument that people are less likely to cycle if it is unsafe, and that if the conditions are safer then they will cycle more. It should be noted that the decreased trend of cyclist fatalities, as shown in Figure 16, are linked by Pucher and Bucher (2008) to the prioritised implementation of cycling facilities. If cycling, walking or other forms of NMT modes are to be encouraged (Rietveld and Daniel, 2004; Pucher and Bucher, 2008), increasing the levels of safety, both actual and perceived, is important. The impact that NMT facilities have on improving safety should, therefore, not be neglected nor should the positive effects that NMT facilities have on increasing the use of NMT forms of transport.



Compared to other countries, including the United Kingdom and the United States of America, The Netherlands maintains high levels of NMT trips, which have been estimated to be 46% of all trips (Jacobsen, 2003). The significant proportion of all trips being NMT trips indicates that NMT, as a mode of transport, can play a significant role in meeting the transport demand and, therefore, managing traffic effectively. This generates significant benefits both on the individual level, as well as the society as a whole (Sælensminde, 2004; Wegman *et al.*, 2007; Pucher and Buehler, 2008). However, the question of how countries or cities can increase their NMT proportion of trips is debated to some degree. This is, due to the various approaches that can be adopted or used. While supporting NMT, as a mode of transport, can be done in several ways, increasing the proportion of NMT trips can initially, seem a daunting challenge. It can, however, be done.

The Netherlands is a good example of how a country can turn the trend of decreasing NMT trips and increasing motorised trips around (Pucher and Buehler, 2008). Due to the mass production of motor vehicles from 1950's onwards, NMT trips became unattractive, as car ownership rapidly increased in The Netherlands, Germany and the United Kingdom (Pucher and Buehler, 2008). However, The Netherlands soon realised that the trend of declining NMT trips (especially cycling) and increasing motorised trips was highly detrimental to urban spaces and inhabitants. This was accentuated in cities that have limited space, and could not afford to accommodate the increasing requirements for PMT (Pucher and Buehler, 2008), thereby forcing them to change the way they travelled sooner than other countries. A brief insight into the structural challenges and existing frameworks that have shaped NMT, as a mode of transport, in South Africa is now presented, after which the potentially benefits of NMT trips for South Africa is then presented.

### 3. REFLECTION OF SOUTH AFRICAN NON-MOTORISED TRANSPORT

To gain insight into the NMT trips in South Africa, the basic contributing factors and systems that underlie NMT, as a mode of transport, need to be explored and are therefore discussed in this chapter. Firstly, the structural challenges and the existing frameworks that guide NMT, as a transportation mode, in South Africa are explored. Afterwards, the various NMT strategies and implementations that have been explored in South Africa are then identified, described and commented upon, in Chapter 3.3. These preliminary sections provide a basis understanding, as well as the motivation, for the strategies that then follow. The unrealised potential of NMT facilities in South Africa is then discussed, resulting in the key NMT approach being identified.

#### 3.1 INHERITED STRUCTURAL CHALLENGES IN SOUTH AFRICA

Historically, the needs of NMT users were not acknowledged in national policies or strategies and consequently, not included in the planning and development of South Africa (Vanderschuren and Galaria, 2003; Behrens, 2005). The historical transport policies and legislation focused heavily on the motorised forms of transport (Walters, 2008), with little consideration of NMT as a mode of transport from a national perspective.

As a consequence, developments in South Africa have, traditionally, been designed to rely heavily on motorised transport (Vanderschuren and Galaria, 2003; Behrens, 2005) and this trend has continued in more recent developments (City of Cape Town, 2014). This is despite an acknowledged awareness that better spatial and land use planning is important in addressing many of the present challenges (City of Cape Town, 2006; NDoT, 2008; City of Cape Town, 2014; NDoT, 2015).

South African settlements have two distinct characteristics, which have a significant impact on NMT trips (Behrens, 2005; City of Cape Town, 2009; Lombard *et al.*, 2007; NDoT, 2014b; Vanderschuren, *et al.*, 2015):

1. Settlements are isolated from each other and have a low mix of different uses (Lombard *et al.*, 2007; NDoT, 2014b; Vanderschuren, *et al.*, 2015);
2. Settlements have low densities, and densities of developments continue to drop. This has resulted in greater distances being travelled and more time and money being spent on commuting (Behrens, 2005; Lombard *et al.*, 2007, STATSSA, 2014).

When taking into consideration that the majority of South Africans do not have access to PMT and are restricted to PT and NMT trips (Behrens, 2013; STATSSA, 2014), it is clear that transport in South Africa has inherited high levels of inequality (Vanderschuren and Galaria, 2003; Behrens, 2004; Özler, 2007; City of Cape Town, 2014).

Recent developments have not incorporated the various characteristics that make NMT trips viable (Vanderschuren and Galaria, 2003; Behrens, 2004; City of Cape Town, 2009). An example of this is the continuation of low density residential developments located on the outskirts of developments (Vanderschuren and Galaria, 2003; City of Cape Town, 2009), a practice which is connected to the spatial and land use planning mentioned above. As can be seen in Figure 17 (Gasson, 2001), the development of Cape Town over the years has resulted in lower levels of densities. Between 1904 and 1946, the population in Cape Town increased by 130% while the density decreased by approximately 36%. The population increased by 110% between 1946 and 1970, while the density continued to decrease by an additional 29%. This trend continued between 1970 and 2000, where the population once again increased by 120% and the density decreased by another 25%. This is counter-productive to sustainable, liveable land use and has resulted to trips and travel behaviours requiring high levels of resources and costs to both the society as a whole, as well as on an individual level.

Further implications of these low density developments, with regards to transport, is that not only is transport expensive, due to increased distances but it also makes more sustainable modes of transport, such as NMT trips and PT trips, difficult to sustainably implement and maintain (Lombard *et al.*, 2007; Dawood and Mokonyama, 2015).

With no significant change in the urban environments, motorised transportation, specifically PMT, remains the preferred dominant mode of transportation (Lombard *et al.*, 2007; Walters, 2008; STATSSA, 2014). This is contrary to the policy objectives that aim to increase the uptake of PT and NMT trips, while reducing private motorised trips (NDoT, 2008; NDoT, 2014b). The lack of an integrated transportation system to places of work, education and other activities, poor quality of PT, the lack of adequate NMT facilities, and road safety concerns are some of the reasons why PMT is preferred above other modes of transport (Vanderschuren and Galaria, 2003; Behrens, 2004; STATSSA, 2014; Dawood and Mokonyama, 2015 ).

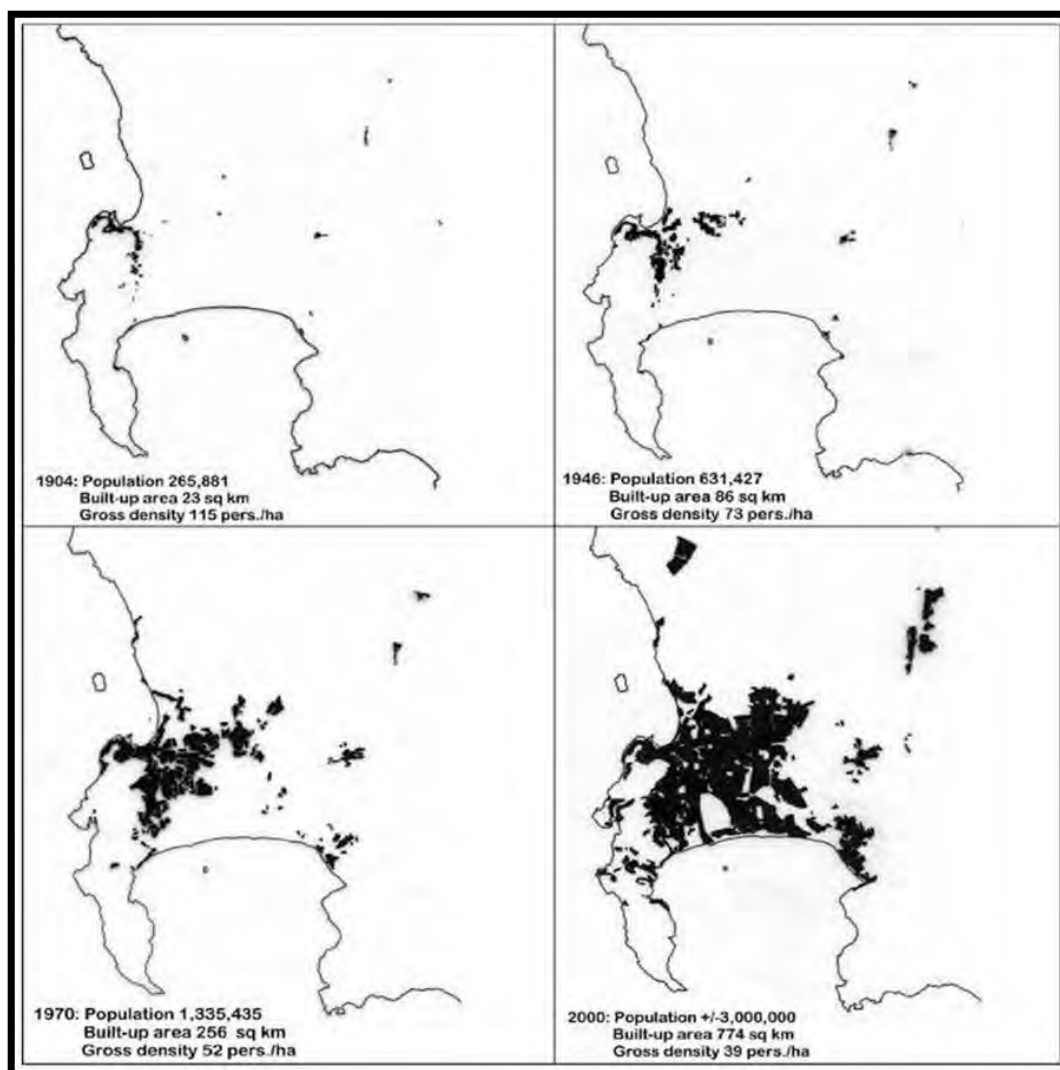


Figure 17: Population Growth of Cape Town 1904-2000 (Source: Gasson, 2001)

These factors have contributed to the mobility and accessibility of South Africans being highly inequitable (Litman, 2002; Vanderschuren and Galaria, 2003; Behrens, 2004; City of Cape Town, 2006). Higher income groups currently enjoy high levels of accessibility and mobility at a proportionally lower cost than that of the urban poor. The urban poor experience not only a proportionally higher cost of transportation, but also lower levels of accessibility and mobility, poorer levels of service, and poorer safety (Litman, 2002; Behrens, 2004; STATSSA, 2014; Dawood and Mokonyama, 2015).

### 3.2 FRAMEWORKS OF SOUTH AFRICAN NON-MOTORISED TRANSPORT

While support for NMT, as a transport mode, has slowly grown in isolated sections of the country, with the first community-driven NMT activities and campaigns occurring in Cape Town in the 1980's (De Waal, 2015), NMT trips were not recognised on a national level until several years later (City of Cape Town, 2006; Department of Transport, 2008). Awareness and support for NMT, as a transport mode, throughout South Africa continued to grow over the years, with more NMT events, bike supply and educational programs being implemented. In parallel to this, the related frameworks in terms of policy, strategies, and guidelines have also received attention.

The first step towards acknowledging NMT, as a transport mode, in policy documents was The *White Paper on National Transport Policy* (NDoT, 1996). This policy formed the strategic objectives for the government's approach to transport planning and development. It was, however, limited in the details of the practical implications of supporting NMT users and NMT trips. Some of the details that were included relate to addressing fundamental principles that influence the viability of NMT trips. These have been emphasised in The *Red Book: Guidelines for human settlement planning and design* (CSIR, 2000). Some of the key points regarding NMT trips include:

- **Work trips should be limited to 40km or one hour travel time in each direction.** Encourages settlements to be as close to places of work and other urban centres as possible, which would allow for an increased number of NMT trips being made.
- **Public transport has been set to a goal of 4:5 to private transport.** Settlement plans should be designed so that residential areas have access to public transport. This may mean implementing an increased number of NMT facilities and Public Transportation stops and stations.
- **Walking distances to public transport facilities should be less than one kilometre.** The desired goal is to have a public transport boarding point around every 400 – 500m. South Africans currently walk much further than 1km to gain access to transportation and other services (Behrens, 2005; Vanderschuren *et al.*, 2015).
- **Settlements should be planned in order to provide a variety of activities close to dwellings.** This type of planning would support and encourage NMT as a mode of transportation while reducing the dependency on fossil fuels.
- **Movement networks should permit direct pedestrian access to places of interest and public transport facilities.** Prioritises the movement of NMT users, helping to make NMT trips direct and efficient.

These key points highlight that NMT trips are considered to be an important mode of transport. It also highlights the relationship between land use and planning and how these elements both have an important role in improving the viability of NMT trips in urban areas of South Africa.

The White Paper (NDoT, 1996) also focuses on addressing the transportation challenges as perceived in the early 1990's (Behrens and Wilkinson, 2001) and introduces the concept of user-centred transport systems. Rather than viewing the individual as a commuter, the term customer is introduced. It also emphasizes that transportation services and facilities should be convenient, safe and comfortable for the users. This description of transportation services and facilities is used in this research within the case study infrastructure assessments of whether facilities are adequate or not. This will be discussed in detail in Chapter 6.

The second step of addressing the NMT challenges was formulating a strategy of how to improve the current situation. The first post-apartheid NMT strategy that was launched was called Vision 2020. It was soon rebranded to The Moving South Africa Strategy (MSA) and formed an important project, following the legislation of the White Paper (NDoT, 1996). The aim of MSA (NDoT, 1998) was to provide a long term strategy in order to realise the goals of the White Paper (Behrens and Wilkinson, 2001). It was also created with the intention of guiding the various role-players in forming the essential and necessary relationships in order for the transport services to be upgraded successfully. MSA introduced several new themes into South African transportation, including NMT, as a transport mode (Behrens and Wilkinson, 2001).

Some of the features within MSA (NDoT, 1998) that are related to NMT trips, included:

- Urban employment activities should be encouraged to locate within mass transport corridors, thereby increasing density and mixed land uses.
- Public infrastructure will be appropriate to each transport corridor and this will be determined by the transport authorities responsible for each corridor. MSA does provide guidelines for transport corridors based on the number of users. Specific guidelines are given for high, moderate and low passenger volume corridor categories.

Thirdly, a specific policy regarding NMT as a transport mode was drafted in order to provide specific policy directives, namely the Draft Non-Motorised Transport Policy for South Africa (NDoT, 2008). The document highlights the importance of NMT trips for South Africans, as well as the various challenges that face NMT users. It also suggests solutions to the problems facing NMT users and NMT trips. Within the Draft Non-Motorised Transport Policy (NDoT, 2008), the key objectives include:

- Increase the role of NMT as a mode of transport in South Africa,
- Integrate NMT trips into public transport trips,
- Provide safe, adequate NMT infrastructure, and
- Sustainably fund NMT development in South Africa.

While the document is still in draft form, it has provided a basis on which local governmental authorities and municipalities can draft and compile their own local NMT policies and strategies with

regards to prioritising and implementing NMT facilities and NMT programs. However, the long delay in finalising the document into a published draft is problematic and suggests a lack of consistent prioritisation regarding the formalisation of NMT as a mode of transport in South Africa.

Lastly, the guidelines regarding NMT facilities in South Africa were first presented under the title of Pedestrian and Bicycle Facility Guidelines (NDoT, 2003). However, as there was no legal requirement for the guidelines to be followed, the degree to which the Pedestrian and Bicycle Facility Guidelines (2003) were adopted and implemented is unclear, especially on a national level. Based on the progress of NMT implementations, the success of the guidelines is seen to be limited. However, the Pedestrian and Bicycle Facility Guidelines (2003) provided a well-researched and comprehensive foundation, which was used as a starting point for the recently revised and expanded NMT Facility Guidelines (NDoT, 2015).

The revision and expansion of the guidelines include new concepts and best practices, such as Universal Access, as well as addressing other identified gaps (NDoT, 2015). The updating of the guidelines also aimed to make the facility guidelines more user-friendly and more applicable to the challenges that face South Africans today.

By improving and expanding the NMT Facility Guidelines (NDoT, 2015), the National Department of Transport hopes that more stakeholders and practitioners will consult the guidelines and implement the recommendations being made. The goal is for South Africa to see improved consistency and quality of NMT facilities based on the principles and designs being promoted in the NMT Facility Guidelines. Whether the greater awareness and advocacy of NMT users in South Africa will be sufficient to increase the compliance of practitioners to the new NMT Facility Guidelines, will need to be investigated in the future in order to determine the effectiveness of this non-legal approach to the guidelines. This has already been raised as a concern by many experts and stakeholders, both in government, as well as practice.



### 3.3 KEY STRATEGIES OF NON-MOTORISED TRANSPORT

As the middle class of South Africa grows, and more individuals start to have the financial means to purchase or access motorised transportation, the number of vehicles in South Africa is set to dramatically increase (City of Cape Town, 2006; Litman, 2007; Kenworthy, 2002). Based on the literature, as well as what has been seen in practice, this has significant implications regarding road congestion, as well as the degeneration of the urban environment (City of Cape Town, 2006; Litman, 2007; Hook, 2003).

South Africa is in a fortunate position that, currently, many trips are still undertaken in the form of walking trips, which are sustainable and lend themselves to public transport trip integration (Statistics South Africa, 2013; Litman, 2007; City of Cape Town, 2005). However, in order for NMT trips not to decline as economic growth increases (Hook, 2003; City of Cape Town, 2006), it is important that NMT trips become more attractive than what they are currently are in South Africa (Behrens, 2005; Department of Transport, 2008, City of Johannesburg, 2009).

Therefore, improving and providing facilities that are suitable and appropriate for all South African NMT users is important. This is especially true if road safety and traffic management is to be successful in the coming years, as South Africa continues to urbanise. While there are many different strategies and approaches that have been tried, the approaches that are now considered to be best practice will be discussed.

In order for an increase in NMT trips to occur, several elements have to be put into place. Both factors that encourage people to take NMT trips over motorised trips, as well as factors that hinder or restrict motorised trips, need to be used in order to generate significant changes in travel behaviour (Pucher and Buehler, 2008; Heinen *et al.*, 2010). Three key general types of strategies that support and encourage NMT as a mode of transport are briefly introduced in the following sections. These key strategies are based on what is described in the literature, as well what is currently seen in South Africa, especially Cape Town, which is used as a case study area later on in the research. In Table 1, a summary of the different strategies with the associated author(s) is provided for easy reference of the supporting literature for the various strategies.

Table 1: Reference Table of Literature for Key Strategies and Initiatives

Type of Strategy / Initiatives	Detailed description	Author / Reference
Key Strategy 1: Supporting legislation, policy, strategies and guidelines	The need for strong political will regarding making sustained changes in transportation	<ul style="list-style-type: none"> <li>• Pucher and Buehler, 2007</li> <li>• Massink <i>et al.</i>, 2011</li> <li>• Vamos, 2014</li> <li>• Verma, <i>et al.</i>, 2015;</li> <li>• Gwala, 2007</li> </ul>
Key Strategy 1: Supporting legislation, policy, strategies and guidelines	The need for a NMT framework / strategy	<ul style="list-style-type: none"> <li>• City of Cape Town, 2005</li> <li>• City of Johannesburg, 2009</li> <li>• Ethekwini Municipality, 2012;</li> <li>• Gwala, 2007</li> </ul>
Key Strategy 1: Supporting legislation, policy, strategies and guidelines	Integration of policies, strategies and guidelines with practices and implementations	<ul style="list-style-type: none"> <li>• Vanderschuren and Galaria, 2003,</li> <li>• Gwala, 2007</li> </ul>
Key Strategy 2: Provision and implementation of NMT facilities and networks	Providing adequate / separate facilities for NMT users from motorised traffic	<ul style="list-style-type: none"> <li>• Heinen <i>et al.</i>, 2010</li> <li>• Garrard, <i>et al.</i>, 2008</li> <li>• Dill, 2009</li> </ul>
Key Strategy 2: Provision and implementation of NMT facilities and networks	Establishing a clear network for NMT users	<ul style="list-style-type: none"> <li>• Gwilliam, 2003</li> <li>• Heinen <i>et al.</i> (2010)</li> </ul>
Key Strategy 3: Education, encouragement and the rights of NMT users	Road safety training for all road users	<ul style="list-style-type: none"> <li>• Pucher <i>et al.</i>, 2010</li> <li>• MacKenzie <i>et al.</i>, 2008</li> </ul>
Key Strategy 3: Education, encouragement and the rights of NMT users	Strong road rights and the priority within the road space for NMT users	<ul style="list-style-type: none"> <li>• Pucher and Buehler, 2007</li> </ul>

### 3.3.1 KEY STRATEGY 1: SUPPORTING LEGISLATION, POLICY, STRATEGIES AND GUIDELINES

The first element that needs to be seen is a strong political will to change the way that individuals travel. Political will is essential for driving legislation, policy and strategies that will enable local governments and municipalities to implement the necessary reforms to make NMT trips more viable and attractive. This has been a central element in the success of Bogotá and other South American cities that have rapidly increased the number of NMT trips over a few years (Massink *et al.*, 2011; Bogotá Como Vamos, 2014; Verma, *et al.*, 2015). It is also characteristic of the developed countries with successful NMT modal shares as previously mentioned (Pucher and Buehler, 2007; Haines *et al.*, 2007).

In South Africa there is some political will, as shown through the generation of the various NMT related legislation, policy and strategies (NDoT, 2008). The City of Cape Town is one example of establishing a NMT framework which supports and directs NMT initiatives (City of Cape Town, 2005). The NMT strategy for the City of Cape Town can be seen in Figure 18.



Figure 18: Non-Motorised Transport Strategy for the City of Cape Town (Source: City of Cape Town, 2005)

Under the NMT strategy for Cape Town (City of Cape Town, 2005), there are various aspects that are considered. These include access, people and communities, economic and social transformation, and environmental sustainability. These aspects are important, as they are integral to whether or not the transport that is established serves the society as a whole, without having detrimental impacts on the society or the environment.

The Integrated Transport Plan 2006-2011 (City of Cape Town, 2009) goes on further to say that NMT trips are recognised as an essential mode of transport and that a culture of NMT and respect for NMT users, must be promoted throughout Cape Town. Programmes and projects that support these policies are to be encouraged, especially those within the public space. Examples that are given include Vehicle Free Days and Night Markets. Lastly, encouraging and supporting the training of officials and stakeholders in terms of NMT planning and infrastructure design is also mentioned as a critical policy for improving NMT as a transport mode (City of Cape Town, 2009).

These frameworks and policies appear to be in place for the major urban areas of South Africa (City of Cape Town, 2005; City of Johannesburg, 2009; Ethekwini Municipality, 2012), which highlights that progress on a policy or strategic level has been achieved in the country. This is an important aspect of providing the necessary frameworks and directives for local authorities and officials. However, while there are some frameworks being put into place, the integration with practices and implementations is still fairly weak (Vanderschuren and Galaria, 2003; NDoT, 2015). Issues with implementations are often related to inadequate funds being allocated to NMT facilities and implementations. Additionally, issues with local government financial frameworks hindering the allocation of funds to the necessary NMT projects and initiatives has also been raised as an issue.

### 3.3.2 KEY STRATEGY 2: NON-MOTORISED TRANSPORT FACILITIES IMPLEMENTATIONS

The next key strategy is improving the physical environment for NMT users by providing adequate facilities for pedestrians and cyclists away from motorised traffic (City of Cape Town, 2005; Ribbens, 2008; NDoT, 2015). The types of facilities that are provided are important, as shown in various studies (Heinen *et al.*, 2010; Garrard, *et al.*, 2008; Dill, 2009). Completely separated facilities are shown to have the biggest positive impact on NMT trips. This is especially true for vulnerable or sensitive NMT users (Garrard *et al.*, 2008; Dill, 2009). Vulnerable users are users who are at high risk of sustaining severe or fatal injuries (Ribbens, 2008). These users include individuals with various mental and physical abilities or disabilities. An example of such a vulnerable user within the transport setting would be a child trying to cross a motorised road. Additionally, users who are socially or economically vulnerable as need to be considered. An example of this type of vulnerable user would be a low-income individual walking to public transport stops along high speed arterial roads from an informal settlement. Unfortunately, these are also the individuals who generally have more limited resources, including accessing adequate health care, when they are involved in a road collision (Behrens, 2004; Ribbens, 2008; City of Cape Town, 2009). In urban areas of South Africa, the successful implementations of completely separated facilities for NMT users is limited or non-existent (Vanderschuren and Galaria, 2003; Behrens, 2004; Ribbens, 2008).

Planning and identifying where NMT facilities are most needed could be done in a comprehensive manner under a NMT master plan. A master plan could systematically suggest and identify where facilities, such as bicycle lanes and pedestrian facilities, need to be prioritised, as well as where secure parking or rental bikes would be best located, taking into account the various attractions and demands of the public. Thus, establishing a clear network for NMT users would help reduce conflicts between different road users and, therefore, help improve road safety as well (Gwilliam, 2003). Ultimately, these improvements will increase the attractiveness of NMT trips.

Working with a master plan would also help identify any broken links in the NMT network that need to be addressed. This is an important element of encouraging NMT trips. If one section is dangerous or unattractive, it is likely that the individual will not make the trip using a NMT mode but will rather

select an alternative mode of transportation. Another aspect of the physical environment that should be considered is ensuring short, direct routes that avoid intersection conflicts with motorised traffic, thereby saving the NMT user time and effort (Gwilliam, 2003).

The importance of a well-connected network for NMT users is mentioned in various studies including that of Heinen *et al.* (2010). The authors go on to mention that other factors, such as shorter travel distance, increased densities, as well as mixed land use, have all been shown to have a consistently positive influence on NMT trips. However, in urban areas of South Africa, these other factors have not been developed or seen in new developments, with densities remaining low and urban sprawl on the increase, as mentioned before. There is also a clear lack of adequate NMT facilities throughout the country, with some areas worse than others (Vanderschuren and Galaria, 2003; Ribbens, 2008; NDoT, 2015), as previously mentioned.

In terms of NMT facilities and implementations, the City of Cape Town (2009) describes several measures to promote NMT as a mode of transport. These include:

- Provision of NMT amenities at municipal buildings (e.g. showers, bicycle parking);
- The development of incentives promoting NMT trips (e.g. public transport allowances, bicycle travel allowances)

While NMT strategies, as described by the City of Cape Town (2009) include:

- Creating safe and attractive bicycle and pedestrian **networks** that serve all citizens;
- Creating safer NMT environments, especially in sensitive areas that have a high percentage of vulnerable users. For example, areas surrounding schools where there is a concentrated movement of children.

The policy and the strategy (City of Cape Town, 2009) resulted in the following key focus areas being identified as important NMT projects:

- Using the existing NMT network plan, expand the NMT network;
- Ensure that cycle ways and pedestrian paths are safe under the institution of a maintenance and upgrade programme;
- Provide cycle storage facilities at key locations to encourage cycle trips to public transport and other services;
- Ensure implementations cater for special needs users. Such implementations include but are not exclusive to dropped kerbs, tactile paving and audible signals at pedestrian crossings;
- Improve the signage of key areas to guide NMT users, most notably tourists and people new to the area.

Additionally, the Transport Users Forum (TUF) was established, with the purpose of ensuring that local government acts within the frameworks, as well as ensuring that appropriate action is followed when the law is not upheld. The City of Cape Town (2009), acknowledges the important role of NMT trips and accepts that NMT users need to be catered for whenever possible.

### 3.3.3 KEY STRATEGY 3: EDUCATION, ENCOURAGEMENT AND RIGHTS OF NON-MOTORISED TRANSPORT USERS

Another important strategy mentioned in the literature is that of providing training for individuals, so that they engage with the road environment in a safe and responsible manner (Pucher *et al.*, 2010). This includes all road users: pedestrians, cyclists, motorcyclists and motorists. This training, normally, is more efficient when combined with other complimentary strategies, such as pro-bicycle programs, events (such as cycling, running, walking events), as well as ensuring that bicycle supply is affordable for lower-income groups. In South Africa, most of these programs of work and initiatives are driven by organisations, such as Arrive Alive (2005), National Department of Transport and SANRAL (MacKenzie *et al.*, 2008).

Another project that is aimed at encouraging cycling in South Africa is the Shova Kalula Bicycle Project (NDoT, 2008), which aims at improving the accessibility and mobility of individuals in rural and peri-urban areas. The project was started in 2001 and has since distributed thousands of bicycles across the country, aiming at increasing the number of cycling trips in these areas as a means to meet the travel demand, while saving people time and improving the efficiency of the trips (NDoT, 2015).

Alongside adequate training and pro-bicycle initiatives, ensuring that NMT users have strong road rights and priority within the road space is an important aspect of both improving the safety of NMT users, as well as making NMT trips attractive (Pucher and Buehler, 2007; City of Cape Town, 2009). This has been a weak point in South Africa. However, the recent success of the Pedal Power Association's campaign of Stay wide(r) of the Rider (PedalPower, 2015), has resulted in better protection for cyclists on roads and has helped to bring an increased awareness to cyclists' rights. This campaign started in Cape Town and similar campaigns have spread to other parts of the country.

While this is a step in the right direction, many people still view cycling and other forms of NMT trips, as secondary and lower status forms of transport. Efforts of increasing awareness and understanding of NMT users will need to continue consistently until there is a culture change towards NMT users. The importance of bringing about a culture change regarding the use of NMT as a form of transport is an important aspect and is explicitly mentioned in the Integrated Transport Plan (City of Cape Town, 2009), while at the same time encouraging more responsible NMT behaviours (City of Cape Town, 2005; Ribbens, 2008). All these components will contribute to South Africa attaining the various benefits of NMT trips, many of which would help address some of the most significant challenges facing the country. This is explored in more detail in the following section.



### 3.4 UNREALISED POTENTIAL OF NON-MOTORISED TRANSPORT IN SOUTH AFRICA

The potential that NMT trips have to address some of the major challenges confronting South Africa is explored in this section. NMT, as a transport mode, has a variety of benefits that could positively impact on several sectors of South Africa (City of Cape Town, 2005; Litman, 2002; NDoT, 2008; City of Cape Town, 2014). The main benefits that NMT, as a transport mode, could generate for South Africa are now described, based on the available literature on the documented NMT benefits, as well as the relevant current aspects of South Africa (Litman, 2002; Vanderschuren and Galaria, 2003; City of Cape Town, 2005; Ribbens, 2008; Mayosi *et al.*, 2009; NDoT, 2015). The benefits presented will focus on those which address the challenges of South Africa that have the larger negative impacts.

There are four sub-sections that deal with the potential safety, health, environmental and equality benefits of NMT as a mode of transport for South Africa. Specific mention is made of the Cape Town context, as the city is later used as the main case study area of this research. The section on the safety benefits of NMT as a transport mode focuses on the challenge of addressing the high number of road fatalities and injuries that South Africa currently experiences, while the health section focuses on the individual health of those that increase their physical activity levels through NMT trips. The environmental benefits highlight the sustainable nature of NMT trips and how it can significantly reduce the amount of emissions and other environmental externalities that motorised transport generates. Lastly, the equality benefits are discussed in terms of how NMT trips can help improve levels of accessibility and mobility of vulnerable members of society, and in so doing, help address the inequalities and social exclusion of previously disadvantaged communities. However, the full range of benefits of NMT as a mode of transport are unlikely to be realised, if NMT trips do not become safe, efficient and convenient (City of Cape Town, 2005).

#### 3.4.1 SAFETY BENEFITS FOR SOUTH AFRICA

One of South Africa's biggest transport challenges is improving the safety of the country's roads. The high volume and severity of road collisions in the country have a significant impact on the society as a whole. The financial cost of road fatalities and injuries in South Africa costs the economy billions, with the latest estimate indicating that the immediate costs of road collisions in South Africa is R306 million (NDOT, 2015). This is only the direct immediate costs, with further costs of the road collisions not being included. Additionally, the societal and emotional costs of such events are both difficult to quantify as they often have far-reaching implications and effects. With NMT users having the highest number of fatalities and injuries (STATSSA, 2009), addressing NMT safety needs is rightly considered a high priority (NDoT, 2008).

In the developing countries, such as South Africa, road collisions, resulting in the death and injury of NMT users, has always been a high proportion of all the fatalities and injuries (Mohan, 2002; Ribbens, 2008; STATSSA, 2009). Reasons given for NMT fatalities and injuries include:

- Poor maintenance of the road environment, including traffic signs, poor visibility, road markings and lack of appropriate fencing,



- Lack of NMT facilities, especially physically separated facilities, such as pedestrian sidewalks and bicycle lanes,
- Lack of visible traffic law enforcement, resulting in excessive speeding, drinking and driving and general disregard for the rules of the road by both motorised and non-motorised users,
- Motorised traffic not giving way to NMT users and aggressive driving styles (Sukhai *et al.*, 2005), and
- Lack of visibility of NMT users.

Despite the acknowledgement of these reasons, effective solutions have been slow to be implemented, with the number of fatalities and injuries on South African roads remaining high (Arrive Alive, 2005; City of Cape Town, 2005; Mabunda, *et al.*, 2008, Western Cape Government, 2015). If significant improvements in the number of NMT fatalities and injuries are to be made, fundamental changes need to be made to how the safety of NMT users is addressed. With specific reference to improving the safety of cyclists and pedestrians, there are essentially two approaches (Wegman *et al.*, 2005). The first approach is to reduce the possibility of a NMT user and motorised users from colliding. The main way to achieve this is to provide completely (or adequately) separated facilities for NMT users from motorised users. However, if this is not achievable, the second option is to decrease the speed differential between different types of road users should be applied.

If the number of NMT fatalities and injuries are reduced, there are several benefits that would be seen. In South Africa, these could include:

- Reduced NMT fatalities and injuries, along with the physical impairments, disabilities and psychological trauma caused by road collisions, and hence a reduced burden on South Africa's resources and society,
- Change of transportation culture, as leaders and participants are involved in implementations and initiatives that assign more priority and resources to improving road safety for NMT users,
- Increased levels of NMT trips, as safety concerns are reduced,
- Increased levels of integration between NMT trips and other modes of transport, making PT more viable and attractive to all South Africans,
- Increased mobility for those who are not legal to drive or cannot drive, as NMT trips become a safe option of transport.

While there may be many more benefits of improving the safety of NMT users in South Africa, the ones highlighted focus on aspects that speak to improving transport as a whole in South Africa.

### 3.4.2 HEALTH BENEFITS FOR SOUTH AFRICA

As mentioned in the previous section, a reduction in the number of road fatalities and injuries would have various benefits in terms of safety; but it would also have an important impact on the health and well-being of South Africans. While an improvement in safety would not only reduce thousands of unnecessary deaths and severe injuries, it would mitigate the reduced quality of life that result from the severe injuries namely in the form of various disorders, disabilities and impairments. This would significantly improve and safeguard the quality of life for NMT users (Mohan, 2002; De Hartog *et al.*, 2010) and other vulnerable road users.

Another health benefit that is more directly related to the individual making the NMT trip, is the significant impact that NMT trips have on Non-Communicable Diseases (NCD). A main contributing factor to NCD is insufficient physical activity. This has resulted in high levels of NCD, such as cardiovascular diseases, diabetes and obesity, which are significant health burdens for South Africa (Dill, 2009; Mayosi *et al.*, 2009; De Hartog *et al.*, 2010; City of Cape Town, 2014).

One of the recommendations that Mayosi *et al.* (2009) present to address NCD, is to increase the levels of physical activities in schools, workplaces, as well as through improving the built environment. Walking and cycling are two forms of exercise that are both beneficial to ones' health and can fulfil transport demand for many trips (De Hartog *et al.*, 2010). In many situations walking trips already do this. However, these trips are often undesirable, due to poor facility provision and the transportation barriers previously mentioned. Ensuring that individuals feel safe and comfortable, while walking or cycling, is an important step in making these NMT trips more attractive to current and potential users (City of Cape Town, 2005; Ribbens, 2008). If NMT trips are more attractive, they are likely to be more frequent (NDoT, 2015), which could then result in the improved health of South Africans (Mayosi *et al.*, 2009; Dill, 2009; De Hartog *et al.*, 2010; City of Cape Town, 2014). With the health burden of NCD increasing, as mentioned earlier, this could have a significant impact on reducing and mitigating the costs and negative implications thereof.

With an increase in NMT trips and, therefore, PT trips, another potential positive result would be the revival of active transport for children and scholars in urban and metropolitan areas. As NMT trips (and PT) become more attractive and the perceived safety associated with these modes improves, parents and care-takers of children would start encouraging their children to take NMT trips or PT trips (or a combination thereof) to school. This will not only help to lower peak congestion levels, but also add important physical activity to children and scholars' daily habits (Behrens, 2005; De Hartog *et al.*, 2010).

Increased physical activity in scholars has a variety of benefits, including improved concentration, reduced NCDs and improved overall health (Mayosi *et al.*, 2009; De Hartog *et al.*, 2010). With South Africa experiencing an increasing rate of child obesity and diabetes, cycling and walking could offer sustainable and practical solutions to addressing these challenges. Increasing NMT trips for children or scholars also has other non-physical benefits, such as improving their spatial and geographical understanding and development, as well as developing a sense of community and ownership of their neighbourhoods (Behrens and Muchaka, 2011). Influencing children to be more connected within their communities will help grow a more equitable and inclusive South Africa, with individuals creating better bonds within their communities, as well as establishing healthier lifestyles and more sustainable travel habits.

### 3.4.3 ENVIRONMENTAL BENEFITS FOR SOUTH AFRICA

NMT trips have various positive implications, both in terms of improving the environment and providing a sustainable means of transportation (Litman, 2002). Cycling is especially effective in terms of meeting the needs of short to medium length trips, while having zero emissions (Litman, 2002). NMT trips also improves the liveability of areas and can increase socio-economic indicators, such as the equity benefits previously mentioned (Heinen *et al.*, 2010; Milne and Melin, 2014).

For South Africa, encouraging sustainable trips is an important part of ensuring that air pollution remains at acceptable levels and that the quality of the environment, especially within urban spaces, does not deteriorate, as development happens (NDoT, 2008; City of Cape Town, 2014). Vanderschuren *et al.*, (2010) highlight that transportation in South Africa has very low levels of sustainability, with over 98% of the transport sector being reliant on fossil fuels. Additionally, the trend of more privately owned motor vehicles being used as a means to commute to work is also growing within South Africa (Mokonyama and Venter, 2007; Vanderschuren *et al.*, 2010). This is problematic as many corridors are already at capacity (Vanderschuren *et al.*, 2010) and congestion levels are only likely to worsen if this trend is not addressed through improving and encouraging people to use public transport and making NMT trips.

Furthermore, unsustainable land use practices, also mentioned by Vanderschuren *et al.*, (2010), are having a significant hindering effect on the viability of public transport and NMT trips in the country. This is reiterated in the Integrated Transport Development Plan of Cape Town (City of Cape Town, 2009). Poor land use and spatial planning is an important aspect that needs to be addressed as the success of transport is fundamentally connected to and reliant on aspects of land use and spatial planning. It is more likely to be successful and sustainable, if a more holistic approach is adopted in practice. This is also more likely to establish developments that are more environmentally and economically more sustainable, as well as less likely to generate excessively long commutes and help establish communities that are also healthier socially.

### 3.4.4 EQUALITY AND SOCIO-ECONOMIC BENEFITS FOR SOUTH AFRICA

In developing safe, convenient and comfortable NMT trips and PT trips (NDoT, 1996), several social inclusion and equality benefits are associated. The first benefit is that individuals, especially those that are considered vulnerable road users or members of society or are sensitive to socio-economic influences (Behrens, 2004), will have improved levels of accessibility and mobility. This is an important aspect of the potential benefits of NMT trips for South Africa, as it has a potential role in addressing the inequalities of the past (Vanderschuren and Galaria, 2003; City of Cape Town 2005; City of Cape Town, 2009; NDoT, 2008; City of Cape Town 2014). Better NMT facilities can help to dismantle the previous and established socio-economic barriers and societal exclusions.

On a more practical level, increased levels of accessibility and mobility through improved NMT trips and PT trips, will result in transportation becoming more efficient and, therefore, more affordable.

Thus, lowering transport costs is another important aspect of improving the equity of transport for vulnerable members of society, which includes the urban poor, women, children, individuals with disabilities and those unable to drive (Haines *et al.*, 2007; Audirac, 2008; NDoT, 2008; City of Cape Town, 2009; Litman, 2012).

The urban poor will benefit the most significantly from improved NMT facilities and therefore improved quality of NMT trips. Currently, the levels of service of transport to these communities are inadequate or non-existent (Vanderschuren and Galaria, 2003; Behrens, 2004). The urban poor of South Africa are, typically, situated on the outskirts of urban developments, making them especially sensitive to increases in the price of transport (Vanderschuren and Galaria, 2003; Behrens, 2004; City of Cape Town, 2009).

Improving transportation gives people better access to employment, education and other activities. Thus it can help enable individuals to move out of poverty into a more sustainable socio-economic bracket, where they can become more self-sufficient (Haines *et al.*, 2007; City of Cape Town, 2009; Lucas, 2011) and have dignity. This is an important benefit considering the high rates of unemployment in South Africa and the importance of stimulating economic growth and opportunities (Vanderschuren and Galaria, 2003; NDoT, 2008). Ensuring that settlements become more liveable will help ensure that the equality levels and the quality of life for all South Africans improve through the country (NDoT, 2008; City of Cape Town, 2009).

However, in Cape Town, despite policy and implementations encouraging PT and NMT trips (Vanderschuren and Galaria, 2003; NDoT, 2008), privately or company owned motor vehicles (PMT) remain the dominant and preferred mode of transport. This holds true even for areas that are relatively well served by public transportation modes, such as the City's CBD area (City of Cape Town, 2014). Furthermore, it was found that the use of PMT increased from 37.8% in 2009 to 42% in 2012 (City of Cape Town, 2014). Considering that this is precisely what the related policies and strategies are discouraging, it is an indication that more needs to be done in order for the intentions of the various policies and strategies that have been developed, to become a reality in practice.

In order to focus the efforts of improving NMT, as a mode of transport, within the South African context, a key strategy is proposed as a way forward to effectively assist in the changes that are needed to develop transport in South Africa. This will be elaborated upon in the following section.

### 3.5 NON-MOTORISED TRANSPORT FACILITIES: IDENTIFIED KEY APPROACH

The implementation of NMT facilities has been identified to be a major weak point of NMT as a transport mode in South Africa. This was found to be consistently mentioned in the literature reviewed, as well as through stakeholder engagements during the revision of the NMT Facility Guidelines. The NMT network throughout the country is very limited and often does not incorporate adequate designs and principles (Vanderschuren and Galaria, 2003; Behrens, 2005; Ribbens, 2008; NDoT, 2008; City of Cape Town, 2009). The lack of NMT facilities could further be seen as limiting the effectiveness of other NMT initiatives, especially those that are aimed at encouraging individuals switching to NMT modes (Behrens, 2005; Pucher *et al.*, 2010; Verma *et al.*, 2015), as the lack of physical NMT facilities does not facilitate this modal shift.

As mentioned in the previous sections, many of the necessary frameworks, in the form of policy, strategies and guidelines, have been established or revised. The main challenges regarding NMT trips seem to remain largely in the physical environment and practicalities of the mode as a form of transport. These challenges range from safety concerns of NMT users making trips and inefficient spatial and land use planning, to simply a lack of NMT facilities on which to make the trip. However, the issue of inadequate NMT facilities has been highlighted in the literature review, the revision of the NMT Facility Guidelines (NDoT, 2015), as well as engagement with stakeholders. Thus, the focus of this work is to investigate NMT facilities in South Africa, to explore the effects that implementing adequate NMT facilities has for NMT trips and NMT users.

The aim of this research, as mentioned in Chapter 1, is to identify the effects that existing NMT facilities have had, as well as exploring possible issues with the manner in which NMT facilities have been rolled out. This will be investigated in detail in Cape Town, as the selected case study. This research aims to show the impact that improving NMT facilities has in terms of (a) increasing the mode of transport's level of attractiveness, (b) the number of NMT trips, and c) having a positive influence on road safety in South Africa. As road safety has been a constant challenge in South Africa, the provision of NMT facilities in a holistic and comprehensive manner may address some of the underlying causes of the high road collisions.

The research that was undertaken has various elements that are combined to establish a comprehensive understanding of the impacts of NMT facilities in urban areas of South Africa. In the following chapter explains the design of the research, and the methods, data collection and analysis that were used.

## 4. RESEARCH METHOD

The chapter outlines the research design and method. The focus of the research is the safety and usage of NMT modes in relation to the implementation of adequate NMT facilities in urban areas of South Africa. Due to the nature of the propositions and research questions in Chapter 1, a mixed method approach was used to investigate the various different NMT aspects. This approach allowed a comprehensive and multi-perspective investigation of NMT implementations to be presented.

### 4.1 METHOD OUTLINE

One of the main motivating factors behind this research was taking into account the local context in terms of the appropriateness of NMT facilities. As the research was focused on several elements of NMT facilities (namely safety, volume of NMT trips and quality of facilities) the method used would have to be able to combine the findings of these various investigations.

As the research aimed to combine both, the quantitative data and the case study infrastructure assessments, a mixed method multiple-case study design (Greene *et al.*, 1989; Baxter and Jack, 2008, Andrade, 2009) was considered an appropriate option. The adopted design approach provides the main framework for the research. This was done, because there were distinct areas that had NMT implementations at different points. It would, therefore, be interesting to compare different areas and implementations with each other, to determine whether the effects of NMT facilities are consistent.

Other research designs were not considered appropriate, due to the nature of the investigations that were intended to be carried out. One of the other research designs that were considered were causal experimental design approaches. However, taking into account all possible 3rd variables would have been unnecessarily complicated and time-consuming. Therefore, the multiple-case study design was selected as the preferred research design to be used. In the following section, the details of the case study design for the research is outlined.

The research aimed to investigate whether the NMT facilities that have been implemented are of a good quality, which would improve the safety of NMT users (EANs) and encourage NMT trips (volumes of NMT trips). There were three main investigations that were carried out. Each main investigation focused on different aspects of NMT as a mode of transport. By using both, assessment methods and quantitative methods, the different aspects could be investigated in the most efficient and rigorous manner.

The wide selection of case study areas also helped to prevent a micro-context of Cape Town being used as the sole research case area. The selection of multiple case study areas, therefore, provided a better indication of all the possible types and characteristics of settlements in Cape Town and, more specifically, was a selection that incorporated areas throughout Cape Town. This is the motivating reason behind having several case studies that have a range of characteristics and locations, instead of



investigating one particular NMT facility implementation. The case study areas were selected to represent all socio-economic groups, as well as older and more recent settlements of Cape Town. Additional areas were selected, with a similar mix of socio-economic characteristics as the cases study areas to act as control areas.

The roll-outs of NMT facilities have occurred at various times and in different areas, which would have influenced the impacts. The adopted method would have to take the different type of implementations and the different timings thereof into account. Considering that NMT facilities that were investigated implemented in South Africa had little standardisation or legal requirements in terms of designs, the quality of the NMT facilities would need to be evaluated as well. The evaluation of the NMT facilities in terms of design was approached in a case study infrastructure assessment manner, using the newly drafted NMT Facility Guidelines as the benchmark for best practice in South Africa.

## 4.2 CASE STUDY DESIGN FOR THE RESEARCH

While there are significant variations in terms of the type of data used or method of data collection or even research strategies (Yin, 1981; Darke, *et al.*, 1998), the case study design can be described as comprising five general parts (Rowley, 2002; Baxter and Jack, 2008). These are namely: propositions, research questions, appropriate data, conceptual framework, and criteria for interpreting findings (Rowley, 2002; Baxter and Jack, 2008). In Table 2, an overview of each proposition with the associated research questions, data and data sources are presented.

Table 2: Summary of Case Study Structure

Proposition	Research Questions	Data	Data Sources
1. In Cape Town there has been an increase in the improvements of NMT facilities over the years.	<ol style="list-style-type: none"><li>1. Where and what type of NMT facilities and implementations have been rolled out?</li><li>2. Are these facilities adequately designed and implemented to serve the safety and usage requirements of the people who use them?</li><li>3. Do these NMT facilities take into consideration the unique challenges of South Africa, namely security concerns, aggressive driving styles and speeding?</li></ol>	<ul style="list-style-type: none"><li>• Details of NMT upgrades and implementations in Cape Town.</li><li>• Visual images of the NMT upgrades and implementations.</li><li>• Visual images of control routes.</li><li>• Criteria for determining the quality of the NMT facilities.</li></ul>	<ul style="list-style-type: none"><li>• Information on NMT Projects (City of Cape Town, 2015)</li><li>• Google Maps</li><li>• National NMT Facility Guidelines (NDoT, 2015)</li></ul>



2. In the areas where NMT facilities have improved, the safety of NMT users has improved.	<ol style="list-style-type: none"> <li>1. How were the fatalities and injuries trends in the case study areas different from the control areas?</li> <li>2. Which case study and control area had the highest initial EAN?</li> <li>3. Were there any changes in the safety trends pre-, during- or post-NMT facility improvements?</li> </ol>	<ul style="list-style-type: none"> <li>• Number of fatalities and injuries of case study and control areas.</li> <li>• Details of when the NMT facilities were upgraded or implemented.</li> </ul>	<ul style="list-style-type: none"> <li>• Collision Data (TCT, 2015)</li> <li>• Information on NMT Projects (City of Cape Town, 2015)</li> </ul>
3. NMT improvements have also had a positive impact on the number of NMT trips.	<ol style="list-style-type: none"> <li>1. What changes in the volume of NMT trips in South Africa can be seen between 2003 and 2013?</li> <li>2. In the case study areas that had NMT facility improvements, has there been a significant increase in the number of NMT trips compared to the NMT trips taken in the control areas of Cape Town?</li> </ol>	<ul style="list-style-type: none"> <li>• Quantitative data of NMT trips on a provincial level.</li> <li>• Quantitative data of NMT trips for the case study and control areas.</li> </ul>	<ul style="list-style-type: none"> <li>• National Household Travel Survey (2003 and 2013)</li> </ul>
4. The quality of the NMT facilities that have been implemented varies considerably with some facilities being adequate, while others being inadequate.	<ol style="list-style-type: none"> <li>1. Do the facilities show evidence of the principles as described in the NMT Facility Guidelines (NDoT, 2015) for the type of NMT facility implemented?</li> <li>2. How do these NMT facility implementation upgrades compare to the facilities in the control areas?</li> </ol>	<ul style="list-style-type: none"> <li>• Details of NMT upgrades and implementations in Cape Town.</li> <li>• Visual images of the NMT upgrades and implementations.</li> <li>• Visual images of control routes.</li> <li>• Criteria for determining the quality of the NMT facilities.</li> </ul>	<ul style="list-style-type: none"> <li>• Information on NMT Projects (City of Cape Town, 2015)</li> <li>• Google Maps</li> <li>• National NMT Facility Guidelines (NDoT, 2015)</li> </ul>

In order to better frame these propositions and research questions, a conceptual framework was adopted for this research. This is discussed in further detail in the following section.

#### 4.2.1 CONCEPTUAL FRAMEWORK

The conceptual framework aims to identify the different elements that will be included in the research, as well as describing the relationships that may be present between the different elements (Miles and Huberman, 1994; Andrade, 2009). The conceptual framework does not aim to display the various relationships between the different elements but rather serves to illustrate the framework of the research which can then be referred to when interpreting the data results (Baxter and Jack, 2008). The conceptual framework for this research, which is shown in Figure 19.

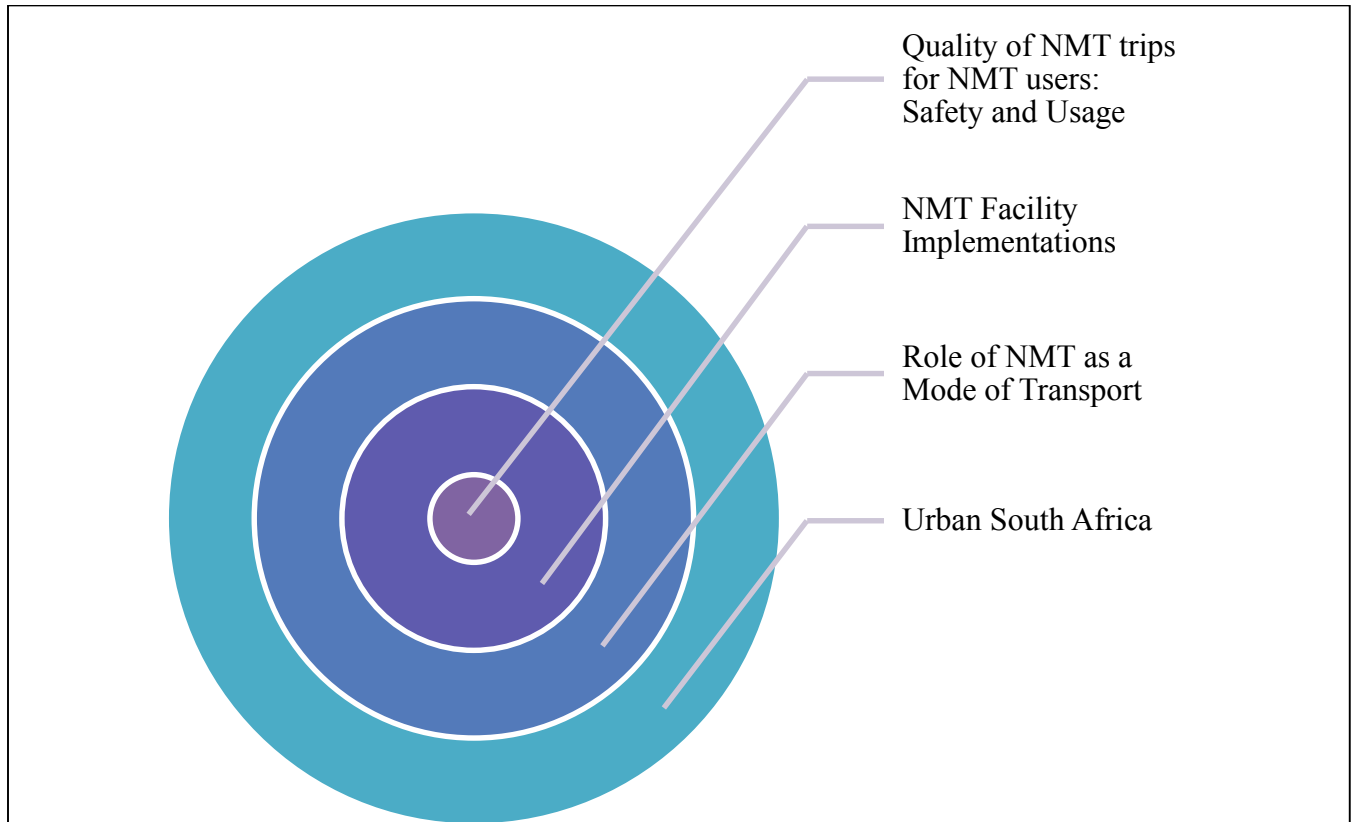


Figure 19: Conceptual Framework for Research: Safety and Usage of Non-Motorised Transport Users

The characteristics of urban South Africa is shown in the conceptual framework to be the underlying element of all the consequential elements. This is a significant motivating reason behind the research, as the context may have a dominant impact on the efforts and implementations that have been carried out in urban areas of South Africa to address the safety and usage concerns. In countries other than South Africa, relationships have been found between increasing NMT facilities, and (a) reduced NMT fatalities and injuries, and (b) increasing the NMT trips. The relationships may not apply to urban areas of South Africa, if the context has an overriding effect. This would have significant implications for future steps regarding how the challenges facing NMT users are addressed. If the relationships

between NMT facilities and improved safety and usage do hold true in the urban areas of South Africa, then this would justify the prioritisation and continued roll out of NMT facilities.

The second lowest level of the conceptual framework is the role that NMT in urban areas of South Africa has, as a mode of transportation. Considering the various benefits of increasing the role of NMT as a mode of transport is explored and is found to be relevant and appropriate for South Africa. This then leads onto the next level of the role that NMT facilities and implementations have in supporting NMT as a mode of transport and enabling NMT users to make NMT trips. The manner in which NMT facilities and implementations are prioritised and, therefore, implemented and maintained will depend on the understanding of how NMT trips can or cannot serve the transportation needs of South Africans. This follows on to the highest conceptual level, which is concerned with the quality of NMT trips based on two aspects, safety and usage. This is the central element in this research. If the experience of NMT trips is improved, NMT users are more likely to experience a more equitable level of transportation, as well as higher levels of safety. They will, therefore, be satisfied and selective NMT users rather than dissatisfied or captive to NMT trips, due to lack of affordability, or captive to motorised modes of transportation, due to concerns of NMT trips.

#### 4.2.2 LINKING DATA TO PROPOSITIONS

The propositions and related research questions had three main elements to them.

1. Safety of NMT users (Proposition 2),
2. Number of NMT trips (Proposition 3), and
3. Level of quality that NMT users experience when they make their NMT trips (Proposition 1 and 4).

As there were distinct elements within the research, the data were collected from three distinct sources and were directly linked to each of the specific elements within the research. Furthermore, research methods were selected as appropriate for each investigation.

Safety was investigated through data of NMT fatalities and injuries in the case study areas and the control areas. The method that was adopted for this investigation is fully described in section 5.1.2. The findings of the investigation were then used in conjunction with the investigation regarding the quality of the NMT facilities, as the design of NMT facilities has an impact on the safety benefit that could be provided from the NMT facility. It was also combined with the investigation into the number of NMT trips, to see whether case study areas that had an increase in the number of NMT trips experienced either an increase or a decrease in the number of NMT fatalities and injuries. This is an important part of the research objectives, which is concerned with showing that the relationships established in other countries regarding NMT facilities hold or do not hold for urban areas of South Africa.

The second element of NMT trips was investigated using the National Household Travel Survey, from 2003 and 2013. This is the most comprehensive transport survey available that contains data that

speaks directly to types of trips and how and when people travel. The main aim of these investigations is to determine if there is a link between the NMT implementations and any increase in the number of NMT users. The full description of the method of this investigation is given in section 5.2.2. These investigations were then compared with the findings regarding safety and the quality of implementation to see if volumes of NMT trips could have been affected by a high incidence of NMT fatalities and injuries, or a poor quality of NMT facility implementations.

The third element of the research focused on determining the quality of the NMT facilities. This relied mostly on visual aids, such as photographs and Google Map images, both current and historic, to evaluate the success of these facilities. The essence of the research method used in these assessments were that NMT facilities were evaluated against the criteria and recommendations as set out in the recently published National NMT Facility Guidelines (NDoT, 2015). For the full description of the research method used, refer to section 6.1.

#### 4.2.3 CRITERIA FOR INTERPRETING FINDINGS

There are three main elements within this research, hence, it was decided that three distinct three sets of criteria would be used to interpret each of the three investigations of the different elements. For the safety aspects, the trends of NMT fatalities and injuries were used as the criteria to determine what type of impact the implementation of NMT facilities were having.

The second element, which is concerned with the usage or number of NMT trips, compared the 2003 and 2013 National Household Travel Surveys. The case study areas and control areas were compared in terms of increases in volumes of NMT trips. The criteria for this element were the volumes of NMT trips. Finally, for the third element, which was the assessments of the NMT facilities, used a scoring system, where the NMT facility implementations were compared against the recommendations in the NMT Facility Guidelines (NDoT, 2015) and given a rating.

### 4.3 TYPES OF DATA

Three distinctly different sources of data were central to the investigations in this research design and method. This was done so that all of the various research questions could be adequately answered. Triangulation is defined as a way to mix various sources of types of data or even research methods (Olsen, 2004; Johnson *et al.*, 2007). The triangulation of the different data sources helped to increase the validity of the evaluation and research findings (Johnson *et al.*, 2007; Yeasmin and Rahman, 2012). Within the case study design framework, including triangulation of data sources is one way to increase the level of objectivity and robustness of the research findings (Olsen, 2004). In the research, the triangulation of the data included both infrastructure assessments and quantitative data. The use of various data sources helped to explore the effects of the NMT implementations from multiple perspectives. This increased the depth of the understanding of the investigation (Olsen, 2004). One advantage of this is not only to answer the proposed research questions and to help validate the

propositions, but also to ensure consistency in the results of the research conducted (Olsen, 2004; Yeasmin and Rahman, 2012).

The questions that were proposed at the beginning of this research would be answered by various sources of data. The investigations were, therefore, divided into two streams of research. Firstly, using the quantitative data that had been identified and sourced, the quantitative investigations were conducted. This helped to identify the implementations that were either succeeding or failing at improving safety and usage within the specific local context.

Whenever possible, a combination of various data was used, in order to verify the proposed findings. This was done for two main reasons. Firstly, it helped develop a more comprehensive understanding of the challenges that face NMT users and implementing NMT facilities in urban areas of South Africa. Secondly, in areas where there were data gaps, of one source of data, a secondary data source could be used to supplement the research.

Through the use of several case study areas of NMT implementations in Cape Town, the degree to which these implementations could encourage NMT trips and NMT users were assessed by comparing what had been implemented to what is recommended in the NMT Facility Guidelines. In addition, key experts in the field were consulted and this provided insights into the current implementations.

#### 4.4 FLOW DIAGRAM OF RESEARCH METHOD

The research was conducted in various steps, which are outlined in Figure 20. For each step of the research process, a short description and the main limitations or assumptions made for that step of the process are given. The method outline is presented first, after which the steps are explained. In the flow diagram, the key research steps are indicated as well as where in the process of this research each step was completed. Steps that are horizontally aligned with each other occurred simultaneously in their undertaking. The arrows indicate where the products of each step provided inputs into the next research step. Further elaboration of the details of each of these steps now follows.

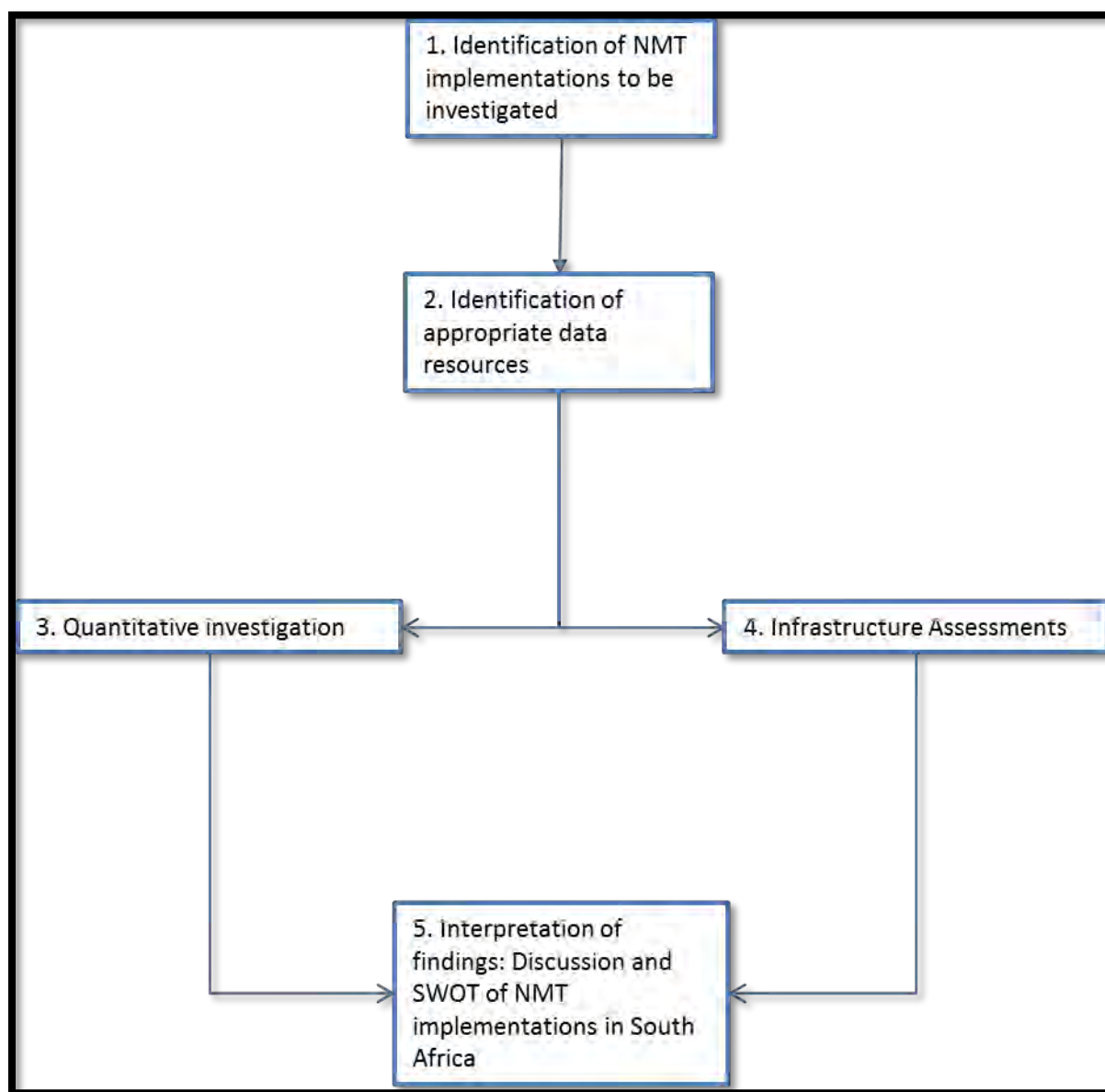


Figure 20: Flow Diagram of Method

*STEP 1: IDENTIFICATION OF NON-MOTORISED TRANSPORT IMPLEMENTATIONS TO BE INVESTIGATED*

Considering the research propositions, a selection of NMT facilities implementations needed to be identified and the details thereof need to be sourced before any investigations could be undertaken. The City of Cape Town's NMT division was contacted in order to obtain details of NMT implementations that were carried out in the Cape Town area. The City of Cape Town provided a list of various NMT facility implementations that ranged in both location, as well as time of implementation. A summary of the information provided can be seen in Appendix A. These suggested

projects were then grouped according to location or suburb, so that nearby NMT facilities created a single case study area. From these groupings, the areas that had the most concentrated NMT facilities implementations were then selected as case study areas. Areas with limited NMT facilities were excluded, as it was assumed that the impacts would be too small to be reflected in the data. Control areas were then selected out of the other suburbs of Cape Town, which had no NMT implementations during the period of time that would be investigated.

### *STEP 2: IDENTIFICATION OF APPROPRIATE DATA RESOURCES*

Through the involvement with the drafting of the new NMT Facility Guidelines, various key stakeholders, experts and organisations were identified as potential sources of data and information regarding NMT implementations.

The main sources or custodians of the relevant data or information were:

- The NMT division at the City of Cape Town: description and details of NMT projects and bicycle fatalities and injuries for Cape Town area (Appendix A)
- Transport for Cape Town (TCT): pedestrian fatalities and injuries
- National Household Travel Surveys (2003 and 2013).

These data sources were then used in the investigations.

### *STEP 3: QUANTITATIVE INVESTIGATIONS*

#### **Non-Motorised Transport Fatalities and Injuries**

The first investigation conducted used the fatality and injury data that had been collected regarding NMT users in the Cape Town area. This included both pedestrians and cyclists. There were, however, concerns regarding the data. The first concern was the under-reporting in the earlier years, namely 2007 up until 2009, and in some areas even as late as 2010. This was evident in the data, as there were sudden increases in the number of fatalities and injuries that a particular area reported, while no major changes in the area had occurred. This concern had been highlighted by the custodians of the data. The second main concern regarding this data was the incomplete or missing information regarding the location of the collisions involving NMT users. However, the method of identifying the appropriate victims of collisions did mitigate this to some degree. While the data was not perfect, it effectively demonstrates the general trends which were the focus of the research questions. As the research objectives were mainly concerned with the overview impact of NMT facility implementations, the data was sufficient for these purposes. Detailed description of this investigation is given in full in Chapter 5.1.

TCT is the City of Cape Town's transport authority and custodian of transport and transport infrastructure in Cape Town (TCT, 2015). The data that was requested and provided by TCT was in



the form of Excel spreadsheets, which were extracted from the Provisional Accident Database of collisions reported between the years 2008 and 2013. These data sets included all reported collisions, both motorised and those involving non-motorised users. By filtering the data, various trends were shown between collisions and the implementation of NMT facilities. The data regarding the bicycle fatalities and injuries were obtained separately from the City of Cape Town (2015).

From these data sets graphs were drawn to illustrate the trends of fatalities and injuries in the form of Equivalent Accident Numbers (EANs) for both the case study areas and the control areas. Pedestrians and cyclists were investigated separately as these users have different facility needs. Therefore, the facilities that have been implemented may only be appropriate for one type of NMT user, while not the other type of NMT user.

After the graphs had been drawn, statistical analysis of whether the changes in the EANs within each case study and control area were done. Additionally, whether the case study areas and the control areas were significantly different overall was also investigated. This was determined by conducting T-Tests on the case study areas and the control areas for pedestrian EANs and cyclist EANs. These tests are presented in Appendix D.

### **National Household Travel Survey**

The quantitative data used in this research was for investigating the number of NMT trips on a national level. Using the National Household Survey of both 2003 and 2013, the changes in NMT trips between these two surveys were investigated. An overall descriptive analysis was conducted as an overview, and then specific investigations were made of the case study areas that have had NMT facilities implementation and the related control areas.

More detailed quantitative data about the NMT trips on a more local level, such as the number of NMT trips on specific routes taken, were not available. However, the case study areas and the control areas could be allocated to the appropriate Traffic Analysis Zones (TAZs) of the National Household Travel Surveys. Therefore, the changes, in the number of trips, of the case study areas could be seen in an aggregated way. The detailed description of the investigation is presented in Chapter 5.2.

The focus of the analysis of the NMT trips was on whether the volume of trips had increased, decreased or stayed the same. Additionally, factors that South Africans considered important when selecting different transport modes and how the priority of these factors had changed was also reviewed, under the general investigation of NMT trips in South Africa.

#### *STEP 4: INFRASTRUCTURE ASSESSMENTS*

The NMT Facility Guidelines (NDoT, 2015) was used in conjunction with visual assessments of the selected case study projects. The visual assessments used Google Earth images, and onsite photographs of the implementations as the data to be analysed. The maps of the areas used in the case study infrastructure assessments are presented in Appendix E for reference. The other two

investigations were considered ‘quantitative’ because they were based purely on the available data and did not have any subjective components.

The newly drafted NMT Facility Guidelines provided clear outlines of what would be necessary for facilities to be viewed as adequate and attractive for NMT users. Therefore, using these guidelines, a case study infrastructure assessment rubric was drafted which focused on key principles that were focused on in the NMT Facility Guidelines (NDoT, 2015). Based on the findings of the first quantitative investigation regarding EANs of NMT users, the best and worst performing case study areas and control areas were selected. Within these areas, routes were selected and Google Maps’ Street-View was then used to scan through the selected routes to determine what rating would be applicable per principle of the rubric per route. From these numeric ratings, principles that are currently poorly implemented or currently successfully implemented could be determined. This helps to guide practitioners and local governments on which principles need more urgent attention and how established principles could be improved further. The full details of this are presented in Chapter 6.

*STEP 5: INTERPRETATION OF FINDINGS: DISCUSSION AND SWOT ANALYSIS OF NON-MOTORISED TRANSPORT IMPLEMENTATIONS IN URBAN AREAS OF SOUTH AFRICA*

In this step the outcomes of the various quantitative and case study infrastructure assessments are combined in order to present the comprehensive understanding that has been developed, through this research. Findings that are consistent with each other are highlighted, as well as those findings that contradict each other. Possible reasons for both are suggested based on the understanding gained through the different investigations.

As a way to summarise and simplify the results of the various investigations, a SWOT analysis of the results was then drafted. This aimed to highlight the progress and the challenges of NMT implementations in urban areas of South Africa in an accessible way, which could then be used in the decision making regarding NMT implementations in the future. This is presented along with the surrounding discussions regarding this research in Chapter 6.2. The final summarised findings of the research are then presented in Chapter 7.

## 5. QUANTITATIVE INVESTIGATIONS

In this chapter the quantitative investigations that were carried out as part of this research are discussed. These investigations are focused on whether NMT trips were becoming safer and increasing volumes of NMT users in areas where NMT facility implementations were provided. The investigations tackle the two areas regarding NMT facility implementations in urban South Africa that were identified in Chapter 4. These two areas are, firstly, the safety impact that the NMT facility implementations are providing for NMT users by reducing the number of NMT fatalities and injuries, and secondly the impact that NMT facility implementations are having on the number of NMT trips in urban areas of South Africa. The first was assessed by investigating the number of NMT fatalities and injuries in areas that have had NMT facility implementations. The second was assessed by investigating the number of NMT trips.

Common elements between the different investigations were used to link the different impacts of NMT facility implementations in urban areas of South Africa together. These common elements include the geographical areas being investigated; type of road users being investigated; as well as overlapping time periods. This was considered important because although NMT facility implementations may improve one aspect, it does not necessarily mean that another aspect, such as volume of NMT trips, will also be positively influenced. For example, while levels of safety may improve as a result of a NMT facility implementation, the number of NMT trips may or may not increase. Therefore, by establishing common elements, variations of NMT behaviour could be seen within the urban South African context that may differ from findings in other countries. These common elements also allowed the findings of the quantitative investigations to be added to the case study infrastructure assessments. The combination of both the assessments and quantitative investigations would then provide a multi-perspective view of NMT facility implementations.

The NMT fatalities and injuries investigations are presented in this chapter. The chapter includes the research approach; method of research; and investigation findings and discussion of these particular quantitative investigations. Similarly, the investigations regarding the quality of NMT trips are also presented.

### 5.1 NON-MOTORISED TRANSPORT FATALITIES AND INJURIES INVESTIGATION

This investigation was critical to answering the research questions related to Proposition 2 in Chapter 4<sup>2</sup>. In order to answer these questions, an in-depth investigation into the NMT fatalities and injuries was needed. The scope of this investigation was the relationship between trends in NMT fatalities and

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<sup>2</sup> These questions include: ‘How were the fatalities and injuries trends in the case study areas different from the control areas?’; ‘Which case study and control areas had the highest initial EAN?’; ‘Were there any changes in the safety trends pre-, during- or post-NMT facility improvements?’

injuries, and the implementation of NMT facilities in urban areas of South Africa. In the following section the general approach to investigating these questions is outlined, after which, the research method is discussed. The findings are then presented, followed by the discussion of the findings.

### 5.1.1 A QUANTITATIVE APPROACH FOR NON-MOTORISED TRANSPORT SAFETY INVESTIGATION

Several case study areas in Cape Town, South Africa were investigated. These were areas that had recent NMT facility improvements or implementations. The selection of these sites was based on information provided by the City of Cape Town (City of Cape Town Non-Motorised Transport Division, 2014) which outlined what NMT facility upgrades had been carried out, and details regarding the time and nature of those implementations.

The control areas were selected to provide indications of what was happening in areas (with no new NMT implementation occurring). This provided insight into general trends affecting NMT trips, NMT fatalities and injuries and NMT facilities that were caused by factors that are outside the scope of this research.

The level of NMT facilities in Cape Town was measured by the number of kilometres of road along which facilities were upgraded. The lengths referred to both pedestrian and/or cycling facilities that had been implemented or upgraded. Due to the limited nature of NMT networks in Cape Town, implementations that had either pedestrian or cycling or both types of facilities were combined in one graph. The case study areas were then ranked by the number of kilometres that were reported to have been upgraded. As can be seen in Figure 21, Atlantis had the most kilometres upgraded, while Milnerton had the fewest kilometres upgraded.

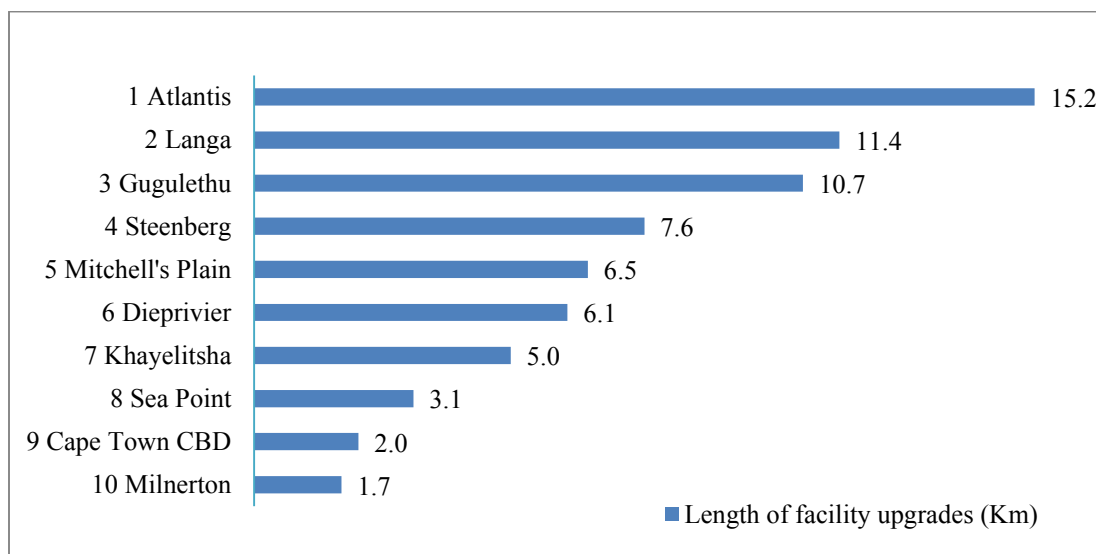


Figure 21: Case Study Areas with Non-Motorised Transport Facility Upgrade Lengths

The selected control areas have a similar mix of socio-economic aspects (income-level, land-use, public facilities and public recreational areas nearby), to the case study areas. Where possible, control areas close to the case study areas were selected. Having control areas close to the case study areas meant that they would experience similar weather conditions and that some of the commuters travelling in these areas would be likely to travel through a control area as well as a case study area. This would help to control for various extraneous factors such as security concerns, weather, land-use (attractions) and other aspects that were not explicitly taken into account in this research. The following six areas were selected as control areas:

1. Philippi
2. Bishop Lavis
3. Ravensmead
4. Kirstenhof
5. Camps Bay
6. Bothasig

The control areas were used to ensure that general trends could be seen separately from trends associated with the implementation of NMT facilities. General trends include projects and implementations that fall under Chapter 3.3.1 and Chapter 3.3.3, as well as negative factors that may also affect NMT as a mode of transport, such as increased levels of alcohol and drug abuse or speeding. The locations of the case study and the control areas are shown in Figure 22, with markers indicating the case study and control areas.

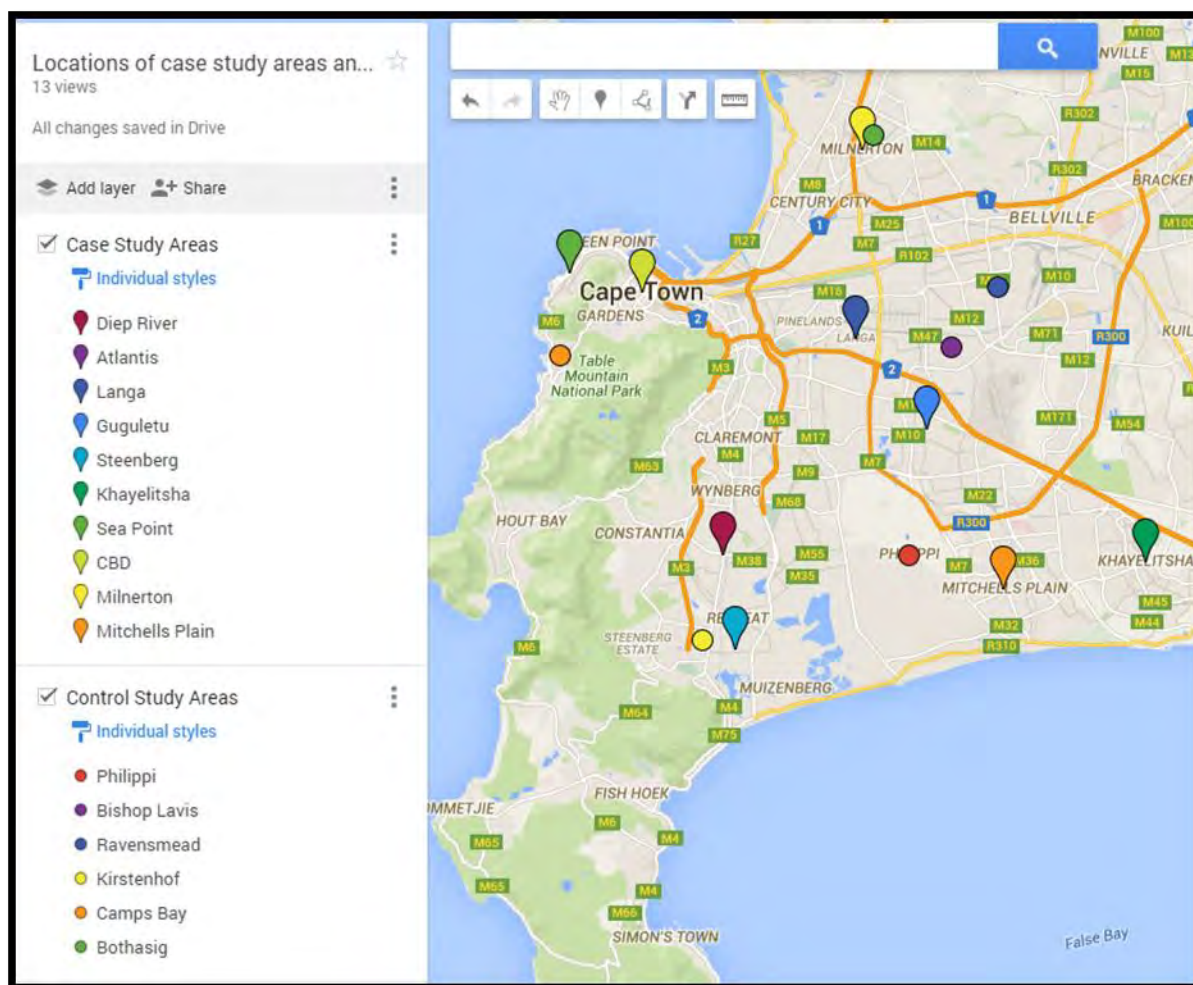


Figure 22: Locations of Case Study and Control Areas indicated with Markers<sup>3</sup>

From Figure 22, it can be seen that the control areas are generally close to multiple case study areas. The only exception is Atlantis, which does not have a nearby control area. However, considering that two of the other control areas (namely Philippi and Bishop Lavis) had similar socio-economic characteristics to Atlantis, it was decided that it was not necessary to find a separate control area close to Atlantis.

While investigating the case study areas, the level of NMT facilities (measured in kilometres) had to be taken into account, as well as the time of the implementations. If the level of implementation was low in a case study area compared to another case study area, then varying results would be expected. Additionally, the different case study areas were divided into three groups based on how many

<sup>3</sup> This map was generated using Google maps (URL: [https://mapsengine.google.com/map/edit?hl=en&hl=en&authuser=0&authuser=0&mid=zKJnhJUgWxR4.kV6nHBtIaJ1k](https://mapsengine.google.com/map/edit?hl=en&hl=en&authuser=0&authuser=0&mid=zKJnhJUgWxR4.kV6nHBtIaJ1k;); Date created: 5 January 2016).



reported kilometres of NMT facilities (City of Cape Town, 2015) had been implemented. The groups were:

- **Group 1 (areas with more than 10km):** Atlantis; Langa; Gugulethu
- **Group 2 (areas with between 5km and 10km):** Steenberg; Mitchells Plain; Dieprivier; Khayelitsha
- **Group 3 (areas with less than 5km):** Sea Point; CBD; Milnerton.

These groups would then be used later in the investigation to compare if there were any relationships between the amount of NMT facility implementation and the impacts that had been seen. The times of the facilities implementations were also important to see whether changes in NMT fatalities and injuries corresponded to these times or not.

The fatalities and injuries were converted into Equivalent Accident Numbers (EANs) for the purpose of the analysis. EANs are a well-established method of combining the different severities of collisions into a common unit (Soemitro and Bahat, 2005). In order to convert the different types of injuries into the single unit of EANs, different weightings were applied to different types of injuries (Soemitro and Bahat, 2005). Fatal injuries were multiplied by a factor of twelve, while serious and slight injuries were multiplied by a factor of three (Soemitro and Bahat, 2005). Collisions that did not result in an injury or when the severity of the injury was unknown were multiplied by a factor of one. This is the standard assigned weighting that is used in EAN calculations (Soemitro and Bahat, 2005). From these weightings, the overall safety trends can be seen. This aligned the data with the focus of the research questions, by allowing the overall trends in NMT injuries to be seen.

### 5.1.2 THE QUANTITATIVE METHOD OF RESEARCH FOR NON-MOTORISED TRANSPORT SAFETY

The method that was used in the investigation regarding the NMT fatalities and injuries is now described. As described under Step 4 of Chapter 4.4, the data was filtered several times for the critical data to be separated from the raw data set. Initially, filtering on the names of the location of the collision was tested as the first step of identifying the relevant collisions. However, this meant that collisions with unknown locations would automatically be excluded at this early stage. It also meant that every potential road in the area would have to be identified within the case study or control area first and then individually selected per area. This would have been unnecessarily time-consuming and tedious. Therefore, this approach was abandoned. The next approach rested on the assumption that collisions were reported to the police station, which was responsible for the area in which the collision had occurred. Therefore, initially filtering by police stations would be a reliable approach that would also include the collisions where the exact location had not been recorded but was known to have happened within the area of that police station. Another major advantage of this approach was that collisions without exact locations would be included under the most relevant area. This meant that



selection made would reflect as close as possible the reality of the NMT fatalities and injuries collisions.

After identifying all potential collisions in the area, the second filter that was applied was that the victims of the collisions were only NMT users. This step excluded drivers of motor vehicles, passengers of motor vehicles, as well as witnesses. From these extractions, the categories of fatalities, serious injuries, slight injuries and no injuries were adjusted to form the EANs of each area investigated. Using the simplified EANs, the trends for both the case study and control areas were computed using Microsoft Excel. Linear trend-lines were added to the graphs with both the equation of the linear trend and coefficient of determination ( $R^2$ ) included. Additionally, points in time when NMT facilities were implemented were indicated on the graphs of the case study areas. This provided graphical representations of the relationships between the NMT facilities and the NMT fatalities and injuries. All the graphs for the case study areas and the control areas are presented in Appendix B and Appendix C. In order to compare the various trends of NMT fatalities and injuries against the linear relationship of the NMT facilities implementations, the coefficient of determination ( $R^2$ ) was used as one measure of how well the modelled linear relationship between increasing NMT facilities and NMT fatalities and injuries fitted (Glantz and Slinker, 1990).

The first analysis was to determine whether the trends that had been illustrated by the graphs were statistically significant or not. This was done by conducting T-tests for each case study and control study area, as well as a T-test comparing all of the case study areas with the control study areas. Pedestrians and cyclists were investigated separately as the data regarding cyclists was provided separately from data used for the pedestrian investigations. Additionally, the facilities may be addressing the needs of one category of NMT user but not the other.

### 5.1.3 FINDINGS AND DISCUSSION FOR NON-MOTORISED TRANSPORT SAFETY

The findings of the NMT fatalities and injuries investigations for cyclists and pedestrians are presented in this section. The focus was not on absolute numbers of NMT fatalities and injuries, but the changes in the number of fatalities and injuries over the years. The time periods on which the analysis focused were: pre-implementation, during implementation, and post implementation. As mentioned before, the control areas were used to take into account general trends of NMT fatalities and injuries in Cape Town where no NMT facilities implementations had taken place. The pedestrian investigations are elaborated upon in Chapter 5.1.3.1, after which the cyclist investigations are given in Chapter 5.1.3.2.

#### 5.1.3.1 PEDESTRIAN INVESTIGATION FINDINGS AND DISCUSSIONS

To sufficiently answer the two questions regarding NMT facility implementations, graphs were generated and a statistical analysis was completed. The work done for pedestrian users in the case study areas and the control areas are now presented. The Equivalent Accident Number (EAN) graphs that were generated are first presented and discussed, after which the T-Tests are presented.

#### 5.1.3.1.1 EQUIVALENT ACCIDENT NUMBER FOR PEDESTRIANS

What was interesting to find, was that case study areas with higher numbers of kilometres did not necessarily result in stronger linear relationships. Group 1 of the case studies had the most kilometres of NMT facilities implemented, but two of the worst  $R^2$ . Group 2 indicated that three of the four had relatively high  $R^2$ . Group 3, which had the fewest number of kilometres implemented, had the third highest  $R^2$ . This can be seen in Table 3.

Table 3: Coefficient of Determinations for Different Case Study Areas<sup>4</sup>

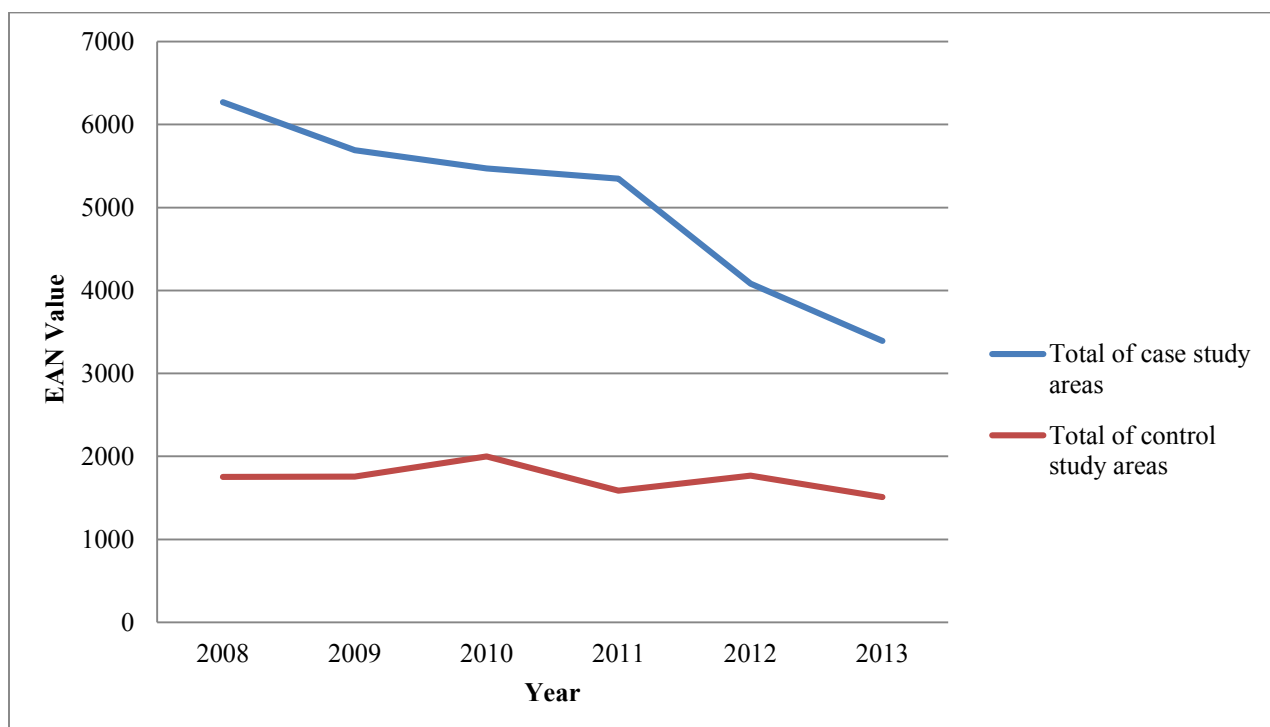
Case study areas	$R^2$	P values
<b>1</b>	<b>0.97</b>	0.0011
2	0.41	0.0404
3	0.38	0.0564
4	0.75	0.000163
5	0.78	0.0001
6	0.36	0.0004
<b>7</b>	<b>0.86</b>	0.0086
<b>8</b>	<b>0.83</b>	0.0067
9	0.60	0.0176
10	0.60	0.000263
Average	0.65	0.0131726

This may indicate that other aspects of the NMT implementations have a role in determining how linear the decline of NMT fatalities and injuries are. These may include factors, such as how well connected the upgraded facilities are to the existing pedestrian network, or how well the NMT facility upgrades have addressed key problematic links or challenges for pedestrians.

When all the EAN of the case study areas were summed together, a strong linear relationship was seen, with the Coefficient of Determination ( $R^2$ ) increasing from the average of 0.65 to 0.9136. This indicates that areas that experience NMT facility upgrades are likely to experience a linear decline of NMT fatalities and injuries in urban areas of South Africa. For the control areas the EANs were similarly summed and Coefficient of Determination also increased from the average of 0.17 to 0.25. This is insignificant and implies a very weak linear relationship in the control areas. This reaffirms that areas in urban areas of South Africa that do not experience NMT facility upgrades are unlikely to have a decline of NMT fatalities and injuries, and as shown in the Figure 23 are likely to remain at the current levels. As the NMT facility implementations were completed over all the years, Figure 23 illustrates the overall accumulative effect of investing in NMT facilities.

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<sup>4</sup> Top three  $R^2$  values shown in bold.



**Figure 23: Total Pedestrian Equivalent Accident Number Trends for Case Study and Control Areas**

For a more detailed view of the changes in each case study areas, their EANs and the time of implementations, refer to Appendix B. Furthermore, from the graphs generated in Appendix B, many of the time periods during which NMT implementations were carried showed faster drops in EANs compared to other periods of time in the area. There were only a few exceptions to this, most notably, Langa, Gugulethu and Sea Point where there were slight increases during some of the time periods of implementation. However, these were minor increases for a relatively short period of the implementation time. Therefore, these findings and discussion regarding the trends of NMT EANs, describe the differences between the case study areas and the control areas for pedestrian. This, therefore, answers the first and third questions in Chapter 4.2.3.2. The first question was how the fatalities and injuries trends in the case study areas were different from the control areas; while the third question centred on whether there were changes in safety trends pre-, during- or post-NMT facility improvements.

The second question of Chapter 4.2.3.2 of which of the areas investigated had the highest number of EANs could also be determined at this stage for the pedestrians. In the case study areas, at the beginning of the investigated time period (2008), Mitchell's Plain had the highest number of 1,645 EAN, while at the end of the investigation (2013) CBD had the highest number of EANs for pedestrians with 734 EAN. While in the control areas for pedestrians Bishop Lavis had the highest number of 640 EAN in 2008 and Philippi had the highest number in 2013, with 569 EAN. While the

first question focused on the trends of EANs in different areas, this question brings into focus the importance of the total number of EANs in areas. Mitchell's plain is a good example of an area that has a history of a high number of EANs for pedestrians. In the investigation of the trends of pedestrian EAN, the declining trend in Mitchell's plain indicates success in addressing the safety of pedestrians, as shown in Appendix B: Figure 62. This may mislead stakeholders to reallocate resources and projects to other areas. However, at the end of the time period, Mitchell's Plain pedestrian EAN were 563. Even though this is a fraction of the EANs in 2008, it is still a high number of EANs as it ranks among the top two worst performing control study areas, Philippi and Bishop Lavis, whose EAN volumes ranged between 640 EAN and 342 EAN. Therefore, additional attention is still needed in Mitchell's Plain despite the positive results obtained thus far.

#### **5.1.3.1.2 T-TESTS FOR PEDESTRIANS**

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The T-Tests were conducted to determine whether the changes for pedestrians in the case study areas, as well as the control areas were significant or not. These were done in Excel, using the additional plug-in software of Real Statistics (URL: [www.real-statistics.com](http://www.real-statistics.com), Date Accessed: 1 January 2016) together with the recorded data of EANs for each individual area.

Depending on the time of NMT facility improvements, the EANs pre- and post-implementations were calculated. If the area had experienced several periods where implementations were carried out, then the earlier years were compared to the later years. In Table 4 this is indicated by "2008/09 vs 2012/13". For the control areas, where no facility implementations were assumed, this was also used. Otherwise the years before the upgrades were compared to the years during and after the upgrades. A summary of these results are shown in Table 4, where Alpha was selected at 0.01 for the T-tests. For each area, all the EAN observations were used in the T-tests. Based on the number of observations for the particular T-test being conducted the degrees of freedom were determined. The P-value and T-critical values were also determined for each area. If the p-value was less than or equal to the selected Alpha value of 0.01 then the relationship was determined to be insignificant. While larger Alpha values are commonly used (i.e. typically 0.5, to ensure 95% level of confidence or 0.1, to ensure a 90% level of confidence), a higher level of confidence was selected to guarantee the confidence of the results considering the small sample sizes and to demonstrate a strong case for the significance of NMT facility implementations.

The full details of these tests can be seen in Appendix D. As Table 4 indicates, 70% of the case study areas had significant changes in the levels of pedestrian EANs post NMT facility implementations. The control areas had only a third of the areas experiencing significant improvements for pedestrians over the period of time investigated.

Table 4: Summary of T-Test Results per Case Study Areas for Pedestrians

Area	Date of Upgrade	P-value	T-critical	Significant
<b>1 Atlantis</b>	2012/13	0.0011	4.540	Yes
<b>2 Langa</b>	2011/13	0.0404	6.964	No
<b>3 Gugulethu</b>	2008/09 vs 2012/13	0.0564	31.820	No
<b>4 Steenberg</b>	2012/14	0.000163	4.5407	Yes
<b>5 Mitchell's Plain</b>	2012/13	0.0001	4.5407	Yes
<b>6 Dieprivier</b>	2012/13	0.0004	4.5407	Yes
<b>7 Khayelitsha</b>	2008/09 vs 2012/13	0.0086	31.8205	Yes
<b>8 Sea Point</b>	2008/09 vs 2012/13	0.0067	31.8205	Yes
<b>9 CBD</b>	2010/12	0.0176	31.8205	No
<b>10 Milnerton</b>	2011/12	0.000263	4.4507	Yes

The results of the control areas can be seen in Table 5.

Table 5: Summary of T-Test Results per Control Areas for Pedestrians

Area	Date of Upgrade	P-value	T-critical	Significant
<b>Control 1: Philippi</b>	2008/09 vs 2012/13	0.0196	31.8205	No
<b>Control 2: Bishop Lavis</b>	2008/09 vs 2012/13	0.0252	31.8205	No
<b>Control 3: Ravensmead</b>	2008/09 vs 2012/13	0.0094	31.8205	Yes
<b>Control 4: Kirstenhof</b>	2008/09 vs 2012/13	0.0519	31.8205	No
<b>Control 5: Camps Bay</b>	2008/09 vs 2012/13	0.0017	6.9646	Yes
<b>Control 6: Bothasig</b>	2008/09 vs 2012/13	0.0212	31.8205	No

Comparing the case study areas to the control study areas, another T-test was performed, which tested positive. This indicated that there was a significant difference between the case study areas and the control areas. NMT facility upgrades had a significant impact on reducing the number of NMT fatalities and injuries. The results of this T-test are shown in Table 6.

Table 6: T-Test between Case Study Areas and Control Areas

T Test: Two Independent Samples									
SUMMARY			Hyp Mean		0				
<i>Groups</i>	<i>Count</i>	<i>Mean</i>	<i>Variance</i>	<i>Cohen d</i>					
Total Case Study	6	5043	1171424						
Total Control	6	1728.667	28895.47						
Pooled			600159.9	4.278216					
T TEST: Equal Variances			Alpha		0.01				
	<i>std err</i>	<i>t-stat</i>	<i>df</i>	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>	<i>effect r</i>
One Tail	447.2732	7.410087	10	1.14E-05	2.763769			yes	0.919749
Two Tail	447.2732	7.410087	10	2.29E-05	3.169273	1896.803	4731.864	yes	0.919749
T TEST: Unequal Variances			Alpha		0.01				
	<i>std err</i>	<i>t-stat</i>	<i>df</i>	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>	<i>effect r</i>
One Tail	447.2732	7.410087	5.246519	0.000285	3.36493			yes	0.955398
Two Tail	447.2732	7.410087	5.246519	0.000571	4.032143	1510.864	5117.803	yes	0.955398

From these various T-Tests, it can be seen, that for pedestrians the NMT implementations had significant impacts in improving safety by the decline in the EANs in the case study, whereas the control areas remained mostly stable. Additionally, in the majority of the case study areas, rates of EANs declined faster during the periods of facility implementations than they did before or after the implementations.

### 5.1.3.2 CYCLIST INVESTIGATION FINDINGS AND DISCUSSIONS

The findings for the cyclist safety and NMT facility upgrades are now presented. These findings were different from those of the pedestrians, indicating that in urban areas of South Africa, these users' needs should be addressed in more specific ways, in order for NMT facilities to be more successful.

#### 5.1.3.2.1 EQUIVALENT ACCIDENT NUMBER FOR CYCLISTS

The graphs illustrating the cyclist EANs in the case study areas showed very weak linear relationships. This may be due to the lower number of EANs that were recorded, which resulted in single fatalities or serious injuries having a greater impact on the overall trend and, therefore, making linear relationships difficult to see. This was confirmed by the  $R^2$  of most of the case study areas being insignificant as shown in Table 7. The only case study areas that demonstrated a significant decreasing linear relationship were Steenberg, Dieprivier, and Milnerton.

Table 7: Coefficient of Determinations for Different Case Study Areas<sup>5</sup>

Case Study Area	R <sup>2</sup>	P values
1	0.0506	0.0093
2	0.0804	0.0352
3	0.0078	0.1211
4	<b>0.6018</b>	0.0015
5	0.1227	0.0031
6	0.4247	0.0022
7	<b>0.756</b>	0.0352
8	<b>0.8643<sup>6</sup></b>	0.0583
9	0.0058	0.0127
10	<b>0.5398</b>	0.0110
Average	0.34539	0.08143

However, while the linear relationship proved difficult to illustrate, the case study areas did seem to decrease overall from their initial levels of EANs in 2009 to the levels of EANs reported in 2013. This is shown in Figure 24.

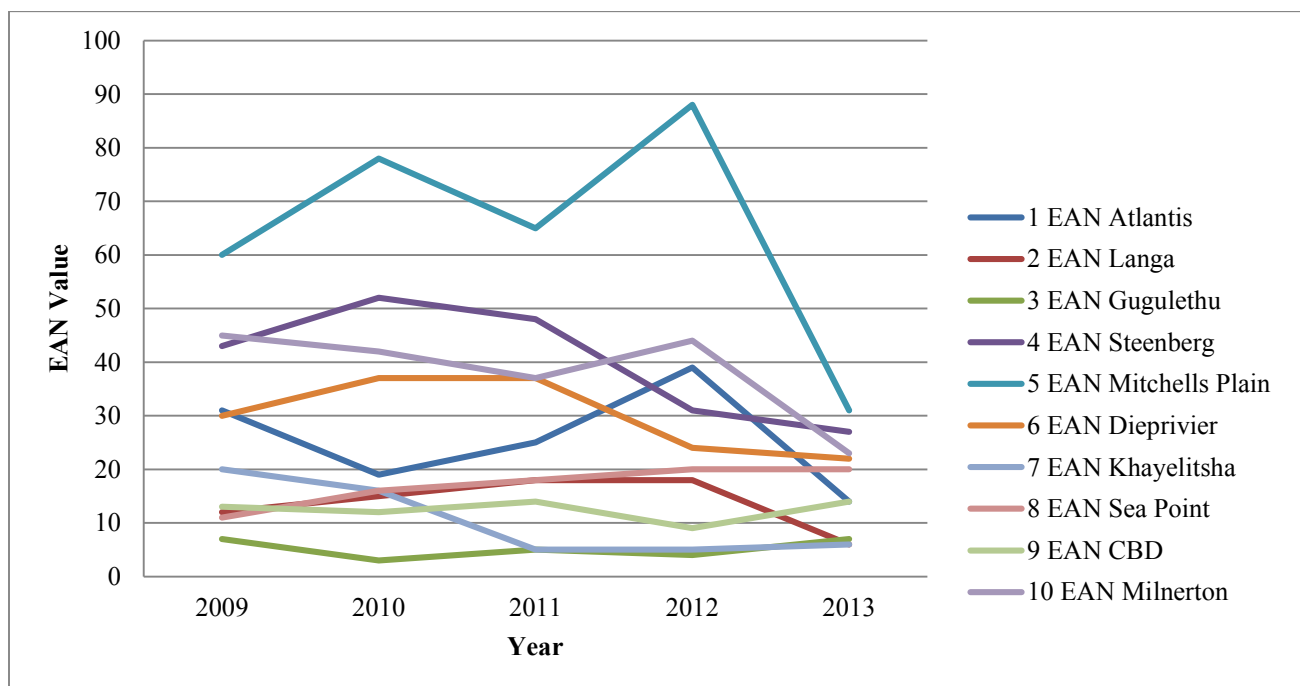


Figure 24: Cyclist Equivalent Accident Numbers in Case Study Areas

<sup>5</sup> Top three R<sup>2</sup> are highlighted in bold.

<sup>6</sup> This was the only increasing trend seen in the case study areas



This is slightly different from the trends in the control areas, which had a greater mix of changes from the initial EAN level to the final EAN level, as shown in Figure 25.

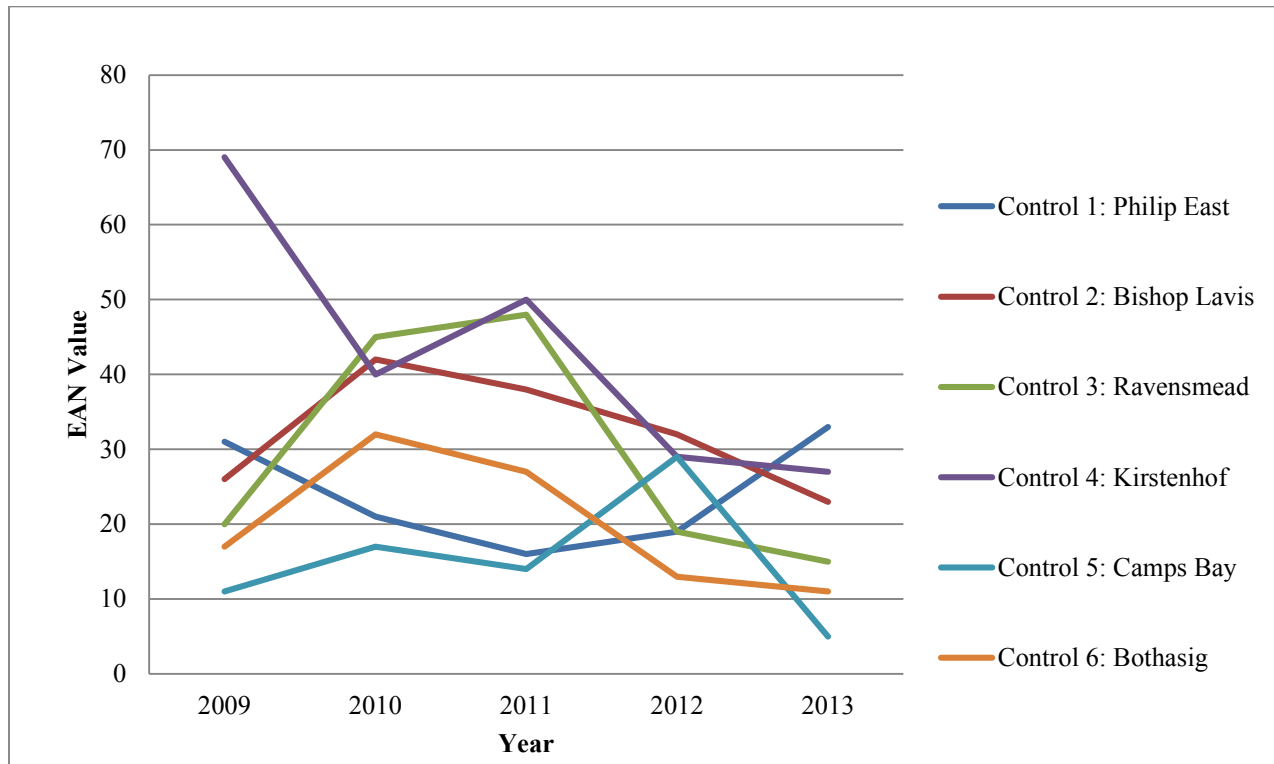


Figure 25: Cyclist Equivalent Accident Numbers in Control Areas

The case study areas and the control areas do not seem to differ much in terms of trends of cyclists EANs, as shown in Figure 24 and Figure 25. Therefore, the impacts that the NMT facility implementations have had in improving the safety of cyclists in urban areas of South Africa seems to be weak. This indicates that the NMT implementations are not successfully addressing the needs of the cyclists. This will be discussed further in the case study infrastructure assessments in Chapter 6.1.4. The results of the T-Tests for the cyclists confirmed this and are presented in the following section.

The second question of which of the areas with the highest number of EANs could now be answered for cyclists. The volumes for the highest case study area and the highest control area were very similar at the start of the investigation and the end of the investigation. Mitchell's Plain was the case study area that had the highest cyclist EAN in 2009, with 60 EAN, as well as the highest in 2013 with 31 EAN. The highest control area in 2009 was Kirstenhof with 69 EAN, while Philippi was the highest control area in 2013 with 33 EAN. From these highest volumes of cyclist EANs, the reported numbers of EAN for cyclists seem to be a small fraction of the EANs that have been reported for pedestrians. This is supported by the literature (Vanderschuren and Galaria, 2003; Behrens, 2004; Behrens, 2005; City of Cape Town, 2005; Statistics Africa, 2005; Gwala, 2007; Mabunda *et al.*, 2008; MacKenzie *et al.*, 2008; Statistics South Africa, 2009; Peden *et al.*, 2013; NDoT, 2015) that indicates that pedestrians

are particularly vulnerable road users in urban areas of South Africa. However, it could also indicate that collisions involving cyclists is either, unreported by the individuals involved in the collisions or uncorrected captured by the system that may not have the structures in place so that these types of collisions can be easily separated from the raw data.

#### 5.1.3.2.2 T-TEST FOR CYCLISTS

Similar T-tests were conducted for the case study areas for cyclist EANs. The summary of the results are shown in Table 8. The results compared to the pedestrians were remarkably less convincing. Only 40% of the case study areas generated a significant improvement. This is, however, more than the control areas, where none of the areas showed any significant changes. This is shown in Table 8 and Table 9. When compared to the pedestrian results, the results of the impact that NMT facilities have had on the cyclists EANs are comparatively less. However, in some case study areas, significant results have been achieved. Thus, the potential for NMT facilities to have a significant impact on the number of cyclist EANs does exist in the urban areas of South Africa. Although, considering the results in section 5.1.3.1.2, the NMT implementations may have been implemented with the focus more on meeting the needs of the pedestrians first before meeting the needs of cyclists.

Table 8: Summary of T-Test Results per Case Study Area for Cyclist Equivalent Accident Number

Area	Date of Upgrade	P-value	T-critical	Significant
1 Atlantis	2012/13	0.0093	6.96	Yes
2 Langa	2011/13	0.0352	31.82	No
3 Gugulethu	2008/09 vs 2012/13	0.1211	31.82	No
4 Steenberg	2012/14	0.0015	6.96	Yes
5 Mitchell's Plain	2012/13	0.0031	6.96	Yes
6 Dieprivier	2012/13	0.0022	6.96	Yes
7 Khayelitsha	2008/09 vs 2012/13	0.0352	31.82	No
8 Sea Point	2008/09 vs 2012/13	0.0583	31.82	No
9 CBD	2010/12	0.0127	31.82	No
10 Milnerton	2011/12	0.0110	31.82	No

Table 9: Summary of T-Test Results per Control Area for Cyclist Equivalent Accident Number

Area	Date of Upgrade	P-value	T-critical	Significant
<b>Control 1: Philippi</b>	2009/10 vs 2012/13	0.0605	31.8	No
<b>Control 2: Bishop Lavis</b>	2009/10 vs 2012/13	0.0736	31.82	No
<b>Control 3: Ravensmead</b>	2009/10 vs 2012/13	0.1169	31.82	No
<b>Control 4: Kirstenhof</b>	2009/10 vs 2012/13	0.0828	31.82	No
<b>Control 5: Camps Bay</b>	2009/10 vs 2012/13	0.0672	31.82	No
<b>Control 6: Bothasig</b>	2009/10 vs 2012/13	0.0946	31.82	No

It is important to remember that currently pedestrians far outnumber cyclists in South Africa. However, if the needs of cyclists are not addressed, then it is unlikely that pedestrians, who could save time and physical effort by cycling, will switch to cycling. In the following section, the changes in the number of the NMT trips are investigated using the National Household Travel Surveys (STATSSA, 2005; STATSSA, 2014).

## 5.2 NON-MOTORISED TRANSPORT TRIPS INVESTIGATION

In this investigation, the objective was to see how the number of NMT trips has changed as NMT facilities have been implemented over the years. The aim was to determine if the number of NMT trips had increased, decreased or remained relatively constant from before the identified NMT facility implementations to afterwards. The changes on the smaller case study area level would then be compared to provincial changes of NMT trips in South Africa. This was done to give an indication of how the Western Cape compared to other provinces, especially the provinces with major urban centres. Any significant differences between the provinces may indicate that the findings of this research may not be applicable to other more urbanised provinces of South Africa. Additionally, by establishing general changes in NMT trips, the changes in NMT trips on the Cape Town level could be viewed within the broader context. The available data used for this investigation was the National Household Travel Surveys (2003 and 2013), which were conducted by STATSSA. This investigation aimed to answer the research questions of the third proposition<sup>7</sup>. The general NMT trip trends on a

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<sup>7</sup> Research questions were ‘What changes in the volume of NMT trips in South Africa can be seen between 2003 and 2013?’ and ‘In the case study areas that had NMT facility improvements, has there been a significant increase in the number of NMT trips compared to the NMT trips taken in the control areas of Cape Town?’.

provincial level are investigated first, before the changes of NMT trips of the case study areas in Cape Town are presented.

### 5.2.1 QUANTITATIVE INVESTIGATION APPROACH

Using the two data of National Household Travel Surveys of 2003 and 2013, both the general changes of NMT trips in South Africa per province and changes specific to the case study Traffic Analysis Zones (TAZs) and the control area TAZs were determined. For the more detailed cases study and control area TAZs in Cape Town, various extracts were made to isolate the necessary data of the selected areas from the raw data of the NHTS (STATS SA, 2003 and 2013). Investigations regarding the changes of NMT trips within the Cape Town case study areas were then done. This would hopefully demonstrate if the NMT facility implementations in the case study areas were generating noticeable changes in the number of NMT trips.

One of the main limitations the data used in these investigation is that trips could not be disaggregated into as small divisions as what had been done in the previous investigation of the NMT EANs. The second limitation of the investigation were that the boundaries of the TAZ zones and the suburbs were not always aligned. While, the majority of the case study areas did correspond to a particular TAZ zone, some of the case study areas fell across two TAZ zones. This only happened for two case study areas, CBD and Mitchells Plain. Thirdly, some of TAZ zones were substantially larger than the case study areas, for the area to be considered as a fair investigation. This was the case for the case study area of Dieprivier, which fell within the TAZ of “Wynberg” which was substantially larger. It is important to note that for the control areas, the spatial difference was not considered to be a concern, as it these areas had not been reported any major NMT facility implementations. Additionally, in terms of defining which TAZs would be considered case study TAZs and which would be considered control TAZs, the following logic was followed:

1. TAZs with only case study areas and no control areas in the TAZ would be defined as case study TAZs.
2. TAZs with case study and control areas in it would also be considered case study TAZs.
3. TAZs with only control areas in it would be considered to be control TAZs.

As the TAZs were generally larger than the case study and control areas of the earlier investigations of this research, it resulted in several of the case study areas and the control areas falling into TAZ. This is shown in the Table 10.

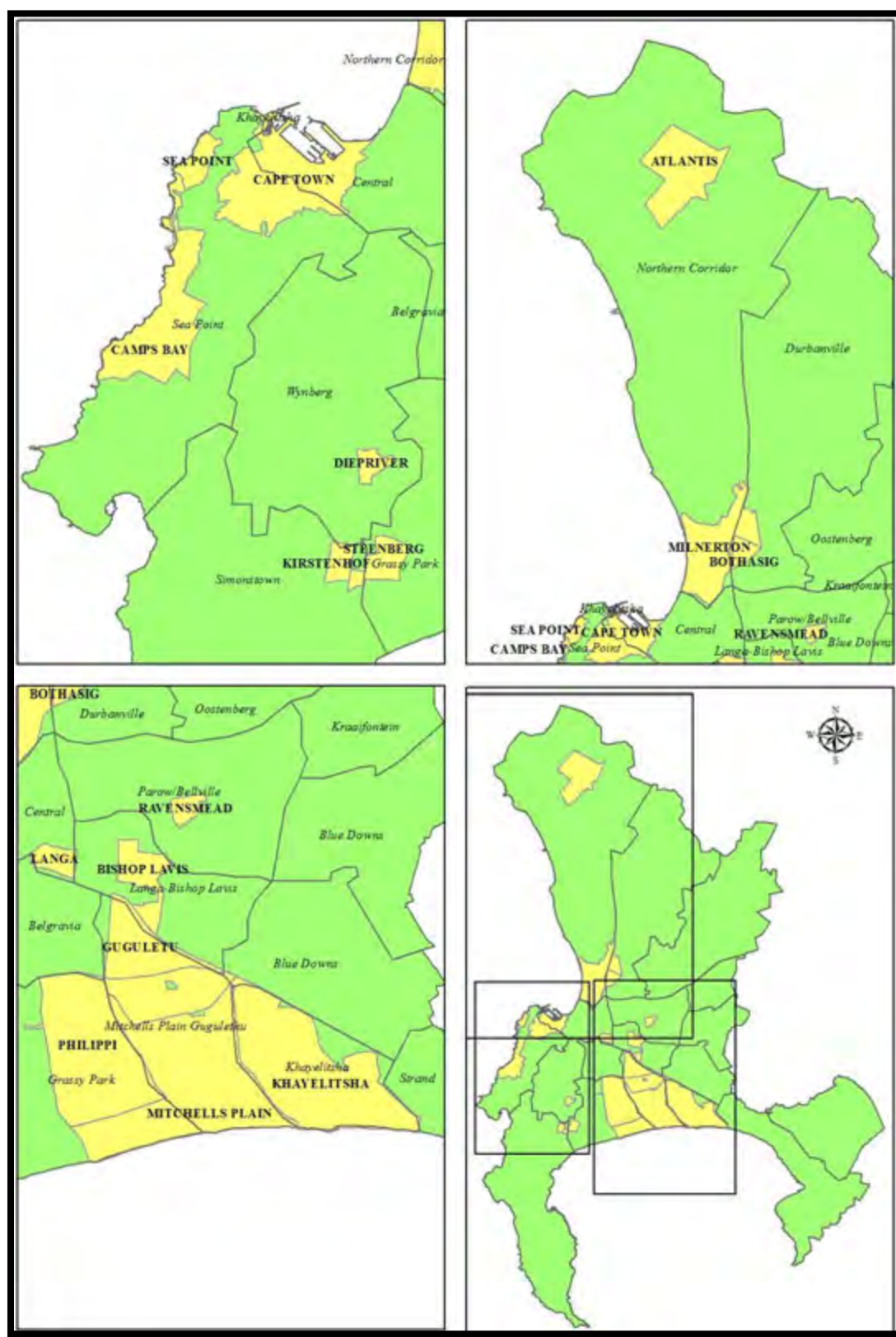
Table 10: Number of Areas per Traffic Analysis Zone in National Household Travel Survey (2003 and 2013)

No.	TAZ Name	Name of Case Study (CS) and Control Areas (CA)	No. of Case Study Areas	No. of Control Areas
<b>Case Study TAZs</b>				
<b>1</b>	<b>Northern Corridor</b>	Atlantis (CS); Milnerton (CS)	2	0
<b>2</b>	<b>Grassy Park</b>	Steenberg (CS); Philippi (CA); Mitchells Plain (CS partial)	1.5	1
<b>3</b>	<b>Mitchells Plain - Gugulethu</b>	Mitchells Plain (CS partial); Gugulethu (CS)	1.5	0
<b>4</b>	<b>Khayelitsha</b>	Khayelitsha (CS)	1	0
<b>5</b>	<b>Central</b>	CBD (CS partial); Langa (CS)	2	0
<b>6</b>	<b>Sea Point</b>	Sea Point (CS); CBD (CS partial); Camps Bay (CA)	1.5	1
-	<i>Wynberg</i>	<i>Dieprivier (CS)</i>	<i>1</i>	<i>0</i>
<b>Control Area TAZs</b>				
<b>1</b>	Parow/Bellville	Ravensmead (CA)	0	1
<b>2</b>	Langa-Bishop Lavis	Bishop Lavis (CA)	0	1
-	<i>Simon's Town</i>	<i>Kirstenhof (CA)</i>	<i>0</i>	<i>1</i>
-	<i>Durbanville</i>	<i>Bothasig (CA)</i>	<i>0</i>	<i>1</i>

As mentioned earlier, Dieprivier was spatially substantially smaller than the TAZ that it was located within (Wynberg). Therefore, this case study area was not considered a justifiable TAZ for the investigations. The two case study areas of the Northern Corridor were in the more populated areas of the TAZ. Therefore, while the case study areas were substantially smaller than the TAZ, it was considered reasonable to include this TAZ as a case study TAZ. For the other case study TAZs the spatial difference between the areas that had received improved NMT facilities were not as substantial. This is shown in the Map 1 and Map 2. In both of the maps, green areas represent the NHTS TAZ areas, while the yellow areas indicate case study and control areas. As there were only 6 case study TAZs, it was decided that two control TAZs should be sufficient for the investigations.







Map 2: Detailed View of Case Study and Control Areas



Next, the method that used to determine the changes in the number of NMT trips in South Africa are described.

### 5.2.2 QUANTITATIVE METHOD OF RESEARCH

For the general changes in NMT trips, the information presented in the summary reports by STATS SA (2003 and 2013), were sufficient to determine the general changes in NMT trips between 2003 and 2013. The information in the two reports were used to generate both Figure 27 and Figure 28.

However, for the second question, of the changes of NMT trips of the case study and control TAZs, additional extracts from the raw data needed to be made along with further investigations. Using the raw data of the NHTS of 2003 and 2013, extracts regarding the selected TAZs, in which the case study areas and the control areas fell into, were made. From these extracts the number of different types of NMT trips determined and the changes between 2003 and 2013 were noted and discussed.

### 5.2.3 QUANTITATIVE INVESTIGATION FINDINGS AND DISCUSSION

The findings and discussions of the NMT trip investigations are presented in two sections. Firstly, the general changes that have been documented in the National Household Travel Surveys of 2003 and 2013 (STATS SA) are presented in Chapter 5.2.3.1, after which the changes within the areas of the case study areas and control areas are elaborated upon in Chapter 5.2.3.2.

#### 5.2.3.1 GENERAL CHANGES IN NON-MOTORISED TRANSPORT TRIPS IN SOUTH AFRICA

The first part of this investigation was concerned with the overall changes regarding NMT trips in South Africa from 2003 to 2013. Two main aspects were investigated:

1. Changes in the percentage of workers who walked all the way to work;
2. Changes in the percentage of learners who walked all the way to their educational institutes;

The changes in the percentages of those that walk as their main mode of transport either to their educational institute or to their place of work were used to gauge how the number of NMT trips had changed over time. Additionally, factors have the most influence on the household's choice of travel mode, as well as how these have changed over the ten year period are elaborated upon. How these factors influence the number of NMT trips is also discussed, as well as what these changes could imply for NMT trips in South Africa.

The changes in the percentage of worker who walked all the way to work were the first investigation that was done. From the 2003 and 2013 surveys, the following changes were calculated per province as shown in Figure 26. The Western Cape, which is the province of the case study areas and control areas in this research, demonstrated an overall decrease of 4.3%. The vast majority of the other provinces also had decreased percentages, with Limpopo Province with the largest decrease of 16%.

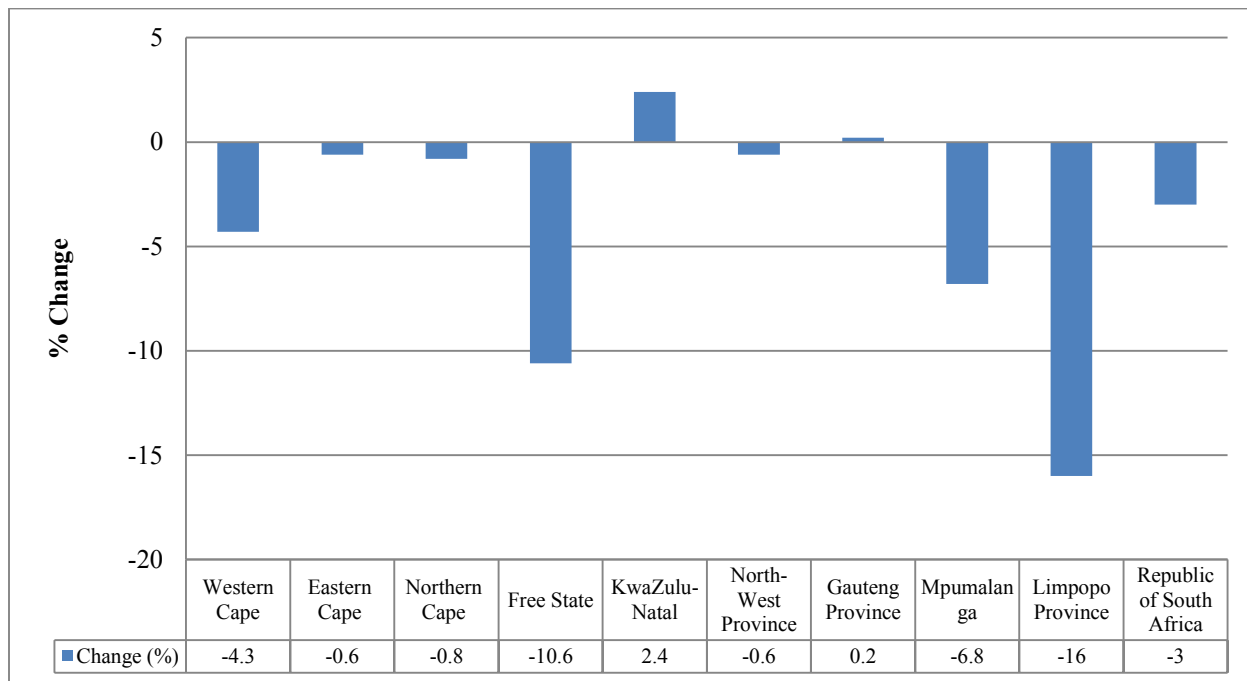


Figure 26: Change of the Workers Who Walked All the Way per Province

The provinces that showed any increase, in the percentage of workers who walked all the way to work, were KwaZulu-Natal (increase of 2.4%) and Gauteng (increase of 0.2%). On a national level, South Africa had a decrease of 3% of workers who walked all the way to work. The Western Cape near to the National average and within the range of the changes seen in the other provinces. Therefore the Western Cape was not considered to be an outlier.

The next investigation done was with regards to the number of learners who walked all the way to their educational institutions. A similar trend of decreasing percentages was seen in these results too, as shown in Figure 27.

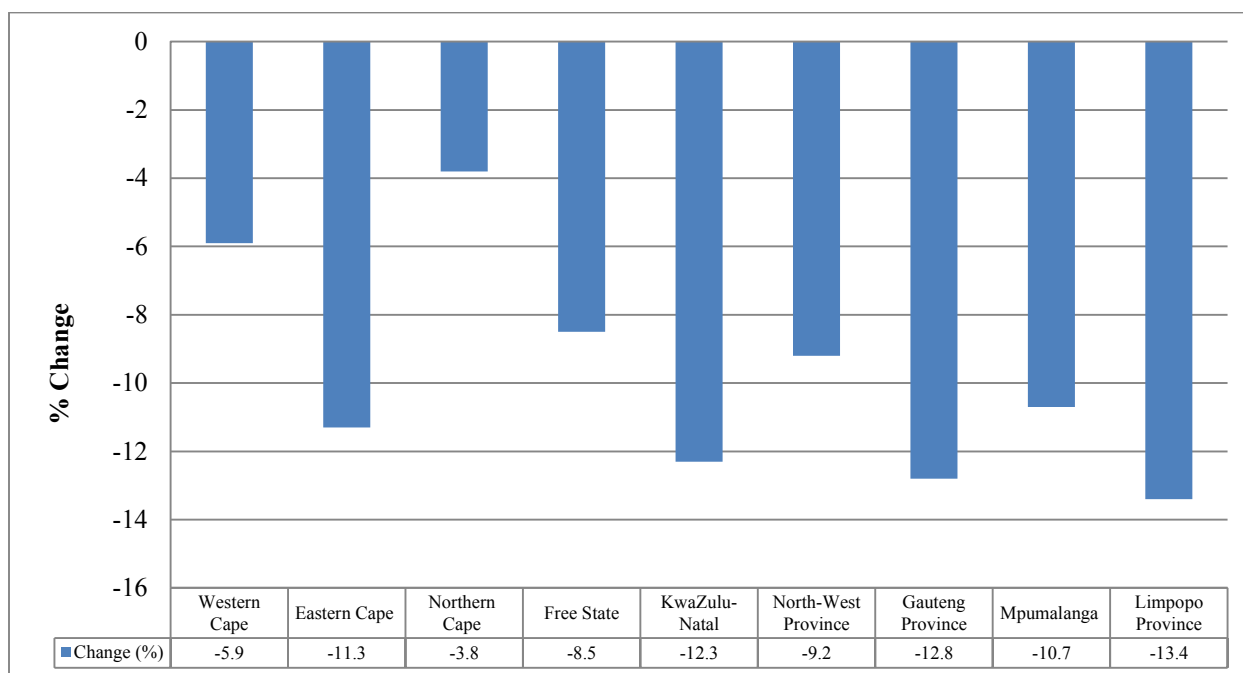


Figure 27: Change of the Learners Who Walked All the Way per Province

The Western Cape, once again also had a decreasing percentage (-5.9%) and none of the provinces showed any increases. Limpopo Province had the largest decrease out of all the provinces of 13.4%, with Gauteng and KwaZulu-Natal close behind with 12.8% and 12.3%, respectively. Once again, the changes in the Western Cape were similar to the other provinces.

These decreasing percentages of walking trips in South Africa indicate that motorised transportation is increasing in its dominance, as NMT trips are being fulfilled by other modes. The strong decreasing percentages of walking trips indicate that not enough has been done in the last ten years to support NMT as a mode of transport in South Africa. Alternatively, too much has been done to prioritise motorised forms of transport over NMT trips.

Next, changes in the factors that influence households' selection of the type of transportation modes were investigated. These changes can be seen in Table 11.

Table 11: Factors that are prioritised in Selection of Transportation Modes<sup>8</sup>

	2003		2013	
Province	Factors prioritised	% of households within province	Factors prioritised	% of households within province
Western Cape	Safety from collisions	46.5	Travel cost	32.9
	Security from crime	20.3	Travel time	22.2
	Travel cost	10.7	Flexibility	12.5
Eastern Cape	Safety from collisions	52.3	Travel time	30.7
	Travel time	12.1	Travel cost	25.4
	Closeness of transport to home	10.9	Safety from collisions	11.1
Northern Cape	Safety from collisions	59.8	Travel cost	30.6
	Travel cost	14.9	Travel time	30.9
	Travel time	12.9	Flexibility	8.9
Free State	Safety from collisions	45.1	Travel cost	24
	Travel time	18.7	Travel time	23.1
	Travel cost	12.2	Flexibility	14.4
KwaZulu-Natal	Safety from collisions	53.5	Travel time	30.9
	Travel cost	14.7	Travel cost	27.4
	Travel time	13.2	Safety from collisions	8.4
North West	Safety from collisions	49	Travel time	43.2
	Travel time	18	Travel cost	19.1
	Travel cost	16.6	Safety from collisions	9.1
Gauteng	Safety from a collisions	45.4	Travel time	36.1
	Travel time	18.8	Travel cost	25.3
	Travel cost	15.4	Flexibility	9.7
Mpumalanga	Safety from collisions	48.7	Travel time	38.1
	Travel cost	21.3	Travel cost	21.1
	Travel time	13.1	Reliability	8.3
Limpopo	Safety from a collisions	40.7	Travel time	34.5
	Travel cost	20.7	Travel cost	28.3
	Travel time	19.8	Flexibility	9.7
Republic of South Africa	Safety from collisions	48.4	Travel time	32.6
	Travel time	15.3	Travel cost	26.1
	Travel cost	14.3	Flexibility	9.2

<sup>8</sup> STATSSA, 2003 and 2013

While ‘Safety from collisions’, ‘Travel time’ and ‘Travel cost’ dominated the factors in 2003, in 2013 ‘Safety from collisions’ was no longer considered as such a critical factor in 2013, with only three provinces mentioning it in their top three factors, while in 2003 it was the most important factor in all of the provinces. While ‘Travel time’ and ‘Travel cost’ continued to be important factors in 2013, the third most important factor in most of the provinces was found to be ‘Flexibility’, however, this was generally the smallest factor out of the top three for any particular province.

Considering that NMT trips can greatly reduce the cost of travel, as well as increasing flexibility (especially for individuals that are captive to public transportation modes), the alignment of the priority factors in 2013 indicate that there is a great potential for NMT trips in South Africa. However, considering the strong importance of ‘Travel time’, NMT trips are likely to continue to decline and/or be considered a minority mode of transport, unless NMT trips become more efficient in South Africa.

#### 5.2.3.2 CHANGES OF NON-MOTORISED TRANSPORT TRIPS IN INVESTIGATED AREAS OF CAPE TOWN

The changes for both the walking and cycling trips, in the case study TAZ’s and the control TAZ’s are now presented the two graphs shown in Figure 28 and Figure 29 respectively. In both graphs, the case study area TAZs are indicated by the darker colour, while the control area TAZs are indicated by the lighter colour. In this investigation, all trip purposes were included in one graph for walking trips, and all trip purposes of cycling trips were presented in the second graph. This helped to generate an overview of whether the NMT facility implementations had correlated to an increase in the number of NMT trips, for any trip purpose.

For the walking trips, out of the six TAZs of the case study areas, four of the TAZs showed positive increases of between 15.6% and 29%. The case study area TAZ of Sea Point only showed a very slight increase of 1.5%, while the case study area TAZ of Central showed a very minor decrease of 0.2%. The control area TAZs were similar to the Central TAZ with very minor decreases, as well (Parow/Bellville of 0.3% decrease and Langa-Bishop Lavis of 0.3% decrease).

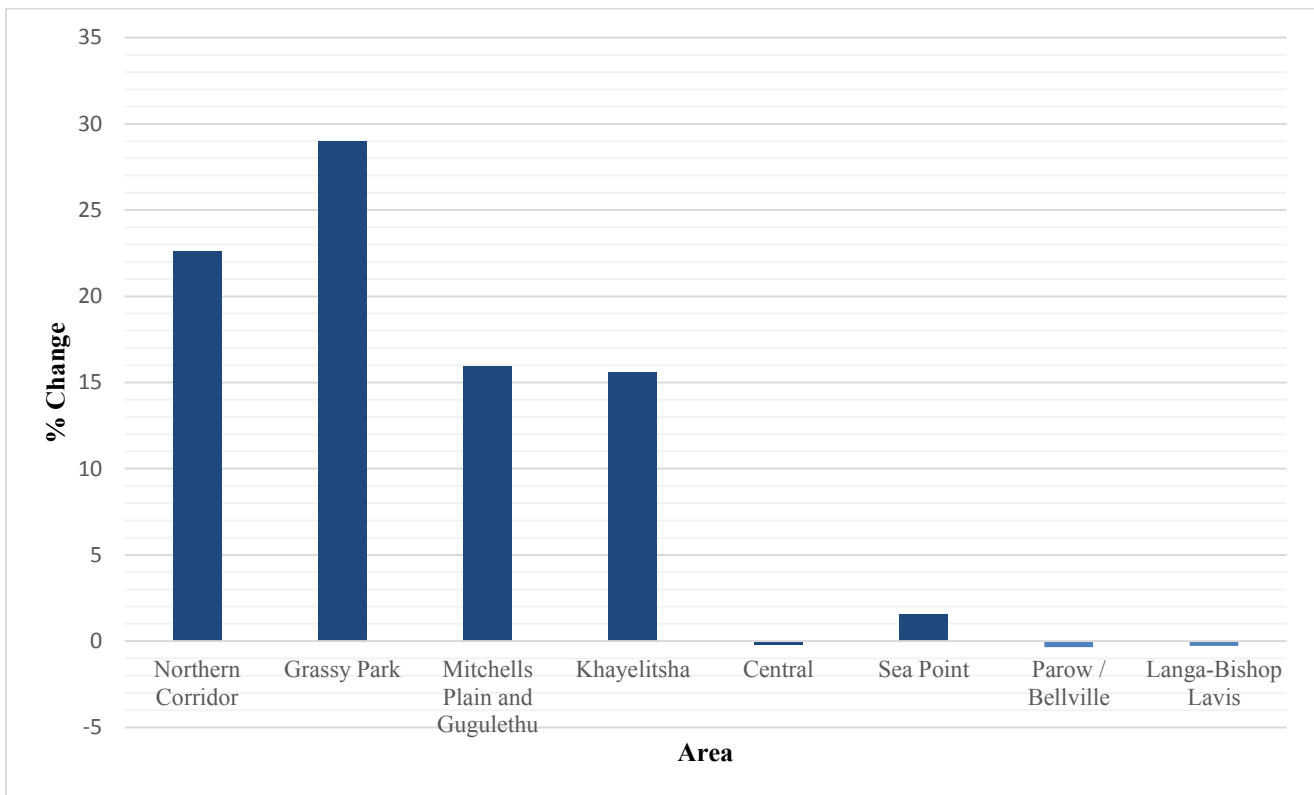


Figure 28: Change of Walking Trips in Traffic Analysis Zones of Case Study and Control Areas

Determining the changes of cycling trips proved to be more challenging as the numbers of trips recorded in the surveys were very small. Therefore, for two of the TAZs that had been identified to do this investigation, there were insufficient entries to be made comparisons between 2003 and 2013.

However, for four of the case study TAZs and both of the control area TAZs, comparisons were made. This is shown in Figure 29. For all the case study areas TAZs and the control TAZ of 'Parow / Bellville', there were decreases in cycling trips of between 0.5% and 0.9%. The only investigated TAZ that had any increase was the control area of 'Langa-Bishop Lavis' which had increased by 2.6%.

The results of the case study TAZs for walking NMT users suggest that NMT facilities have had a positive impact on the number of trips for all trip purposes. However, for cycling there is no evidence that the NMT facilities that have been implemented have had any impact in the case study TAZs in terms of supporting the number cycling trips when compared to that control areas. This once again reiterates the findings of the NMT EANs results that the NMT facilities that have been implemented are not addressing the needs of the cyclists, both in terms of reducing injuries and by increasing the number of trips. However, for NMT users that walk, the NMT facilities have shown again to have positive impacts as walking trips have increased in the case study TAZs. This is encouraging, as the

investigation in Chapter 5.1, also shows positive benefits of reduced pedestrian EANs in the case study areas.

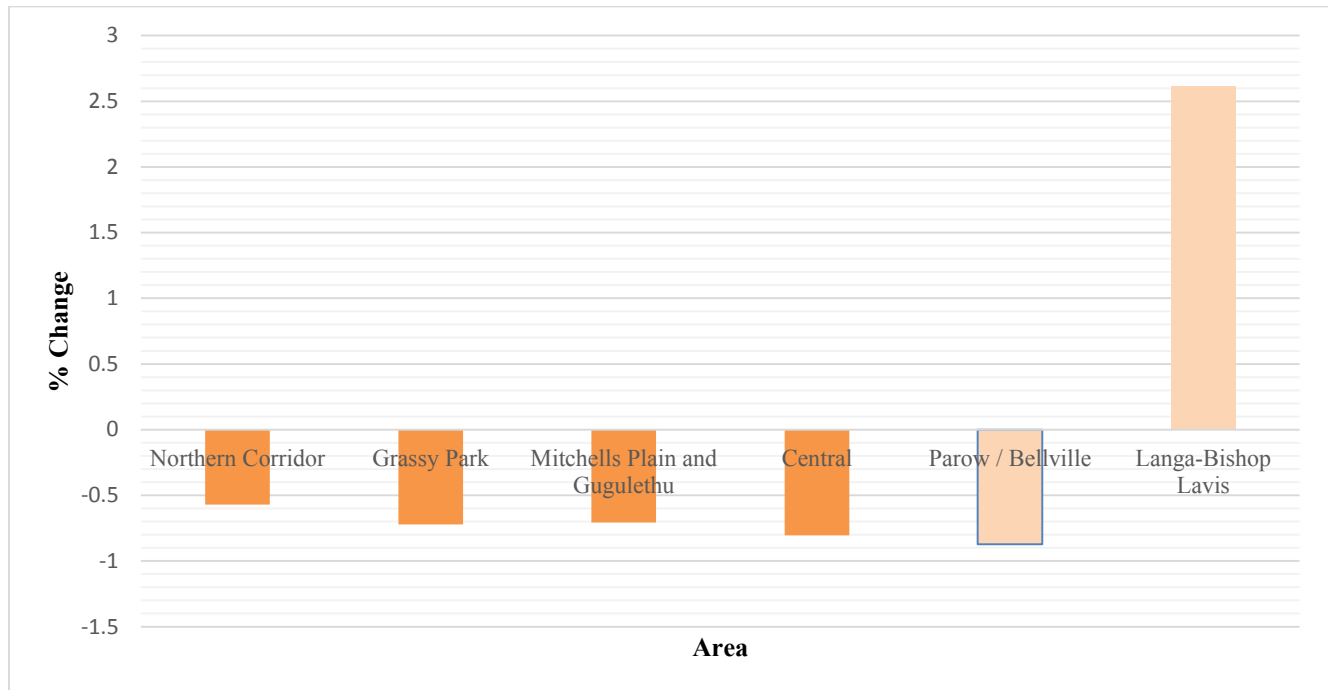


Figure 29: Change of Cycling Trips in Traffic Analysis Zones of Case Study and Control Areas

The manner in which the NMT facilities were implemented could be improved upon. The NMT facility implementations were often implemented in isolation from other NMT implementations which resulted in an increased number of different areas receiving improvements but the overall NMT network remaining fragmented. This was because the focus from a governmental perspective was on allocating NMT facility implementations to as many areas as possible, rather than focusing on building a well-connected NMT network, in structured stages. Establishing a more integrated network is especially important for cycling trips which tend to be selected for longer NMT trips.

The lack of integrated of NMT facilities was one of the main concerns that were raised by the experts in the interviews regarding NMT facility implementations in Cape Town (De Waal, L, 2015; Pretorius, 2015). To address this concern, the NMT facility implementations should focus on achieving a well-connected NMT network that would serve the needs of maybe fewer identified communities before attempting to meet the needs of those living in another area. In this manner NMT trips would be better supported as the NMT facilities would meet the needs of the NMT users for the entire NMT trip instead of only for selected links. Therefore, reducing the number of broken links or barriers that face NMT users, which deter them from making a NMT trip in the first place would have a significantly positive impact on the number of NMT trips.



## 6. CASE STUDY INFRASTRUCTURE ASSESSMENTS

The case study infrastructure assessments of the case study areas and the control areas are presented in this chapter. The foci of these assessments were the design and implementation of the NMT facilities. The objective of investigating these aspects of NMT facilities was to document the quality, successes and challenges that are currently seen in NMT facilities in urban areas of South Africa. Additionally, the investigations were conducted in order to answer some of the research questions<sup>9</sup>. The approach that was adopted for these investigations now follows.

### 6.1 INFRASTRUCTURE ASSESSMENTS APPROACH AND METHOD OF RESEARCH

The approach that was used included the following main steps:

1. Based on the quantitative findings, case study areas and control areas were identified for case study infrastructure assessments. Within the case study areas, the NMT facilities that had been upgraded were identified and mapped out using Google Maps. For the control areas a short route was selected within the area. As the case study areas tended to include main points of access to higher order roads, schools or public transport stations, routes were worked out within the control areas to include these features.
2. Criteria and guiding principles were selected from the NMT Facility Guidelines (NDoT, 2015). These criteria and principles were selected so that they would be applicable to both pedestrian and cyclist users. From these criteria and principles, an infrastructure assessment ranking rubric was drafted. This rubric would then be used to assess the selected case study infrastructure.
3. Google Maps was used to view the case study routes and control routes. In some of the routes, historical images could be accessed which added insight into how the route or area had changed over time. However these historical images were not available for all the routes.
4. Using a collection of images from Google Maps, the routes were then given ratings for each of the criteria on the generated rubric. It is important to note that not every single NMT aspect is discussed but rather critical NMT aspects are highlighted for each case study infrastructure assessment. An overall impression of the NMT facility is then generated through the ratings.
5. Main findings and conclusions were then summarized.

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<sup>9</sup> The research questions referred include: 'Where and what type of NMT facilities and implementations have been rolled out?'; 'Are these facilities adequately designed and implemented to serve the safety and usage requirements of the people who use them?'; 'Do these NMT facilities take into consideration the unique challenges of South Africa, namely security concerns, aggressive driving styles and speeding?'; 'Do these facilities show evidence of the principles as described in the NMT Facility Guidelines (NDoT, 2015) for the type of NMT facility implemented?' and 'How do these NMT facility implementation upgrades compare to the facilities in the control areas?'

It is important to note that this method of case study infrastructure assessments had several limitations that could be improved upon, as mentioned in Chapter 1.4. Although the method used includes potential bias, with the available resources, this was the most practical way to conduct the investigations. The major concerns with these assessments were that the ratings were not conducted in a blind manner. In other words, the reviewer knew both which areas had been upgraded or not and what the safety trends of each area was. In future research, the reviews should be conducted with the reviewer not knowing these additional aspects of the NMT facilities, so that the results are not potentially biased by the reviewer knowing which areas had received upgrades or implementations. In a similar manner, the reviewer should also not know which areas had improved in EANs for the different NMT users.

### 6.1.1 STEP 1: IDENTIFICATION OF ROUTES AND FACILITIES

The selection of case study areas and control areas was based on the results of the first quantitative investigation comparing NMT fatalities and injuries between case study areas and control areas. The best and worst case study areas for pedestrians and cyclists were selected. The criterion for the selection of which areas would be qualitatively assessed was the relative percentage change in EANs for each type of road user, shown in Table 12 and Table 13. The percentage improvement of each case study area and control area was calculated from the first EAN against the last EAN in 2013. The case study area with the largest proportional drop in pedestrian EANs was Mitchell's Plain with 66% decrease, while the worst performing case study area was Dieprivier with a decrease of pedestrian EANs of 20%. For cyclists, Khayelitsha demonstrated the best EAN results with a 70% reduction of EAN, while Sea Point had the worst change with a 82% increase in EANs.

Table 12: Relative Changes in Equivalent Accident Numbers for Pedestrians and Cyclists<sup>10</sup>

	Pedestrian	Cyclist
1 EAN Atlantis	-60%	-55%
2 EAN Langa	-59%	-50%
3 EAN Gugulethu	-43%	0%
4 EAN Steenberg	-30%	-37%
5 EAN Mitchells Plain	-66%	-48%
6 EAN Dieprivier	-20%	-27%
7 EAN Khayelitsha	-30%	-70%
8 EAN Sea Point	-48%	82%
9 EAN CBD	-38%	8%
10 EAN Milnerton	-24%	-49%

<sup>10</sup> Best and worst case study areas highlighted in green and red respectively

The control area with the best performance for pedestrians was Bishop Lavis with a decrease of 33% and the worst performing control area for pedestrians was Philippi. Bothasig had the same poor performance for pedestrians but since Philippi also had the worst performing rate for cyclists, this control area was selected to be assessed. The control area with the best performance for cyclists was Kirstenhof with a 61% decrease in EANs.

Table 13: Relative Changes in Equivalent Accident Numbers for Pedestrians and Cyclists<sup>11</sup>

	Pedestrian	Cyclist
<b>Control 1: Philippi</b>	<b>9</b>	<b>6</b>
<b>Control 2: Bishop Lavis</b>	<b>-33</b>	-12
<b>Control 3: Ravensmead</b>	-16	-25
<b>Control 4: Kirstenhof</b>	-7	<b>-61</b>
<b>Control 5: Camps Bay</b>	-31	-55
<b>Control 6: Bothasig</b>	9	-35

The selected case study areas and control areas were then identified and marked in Figure 30.

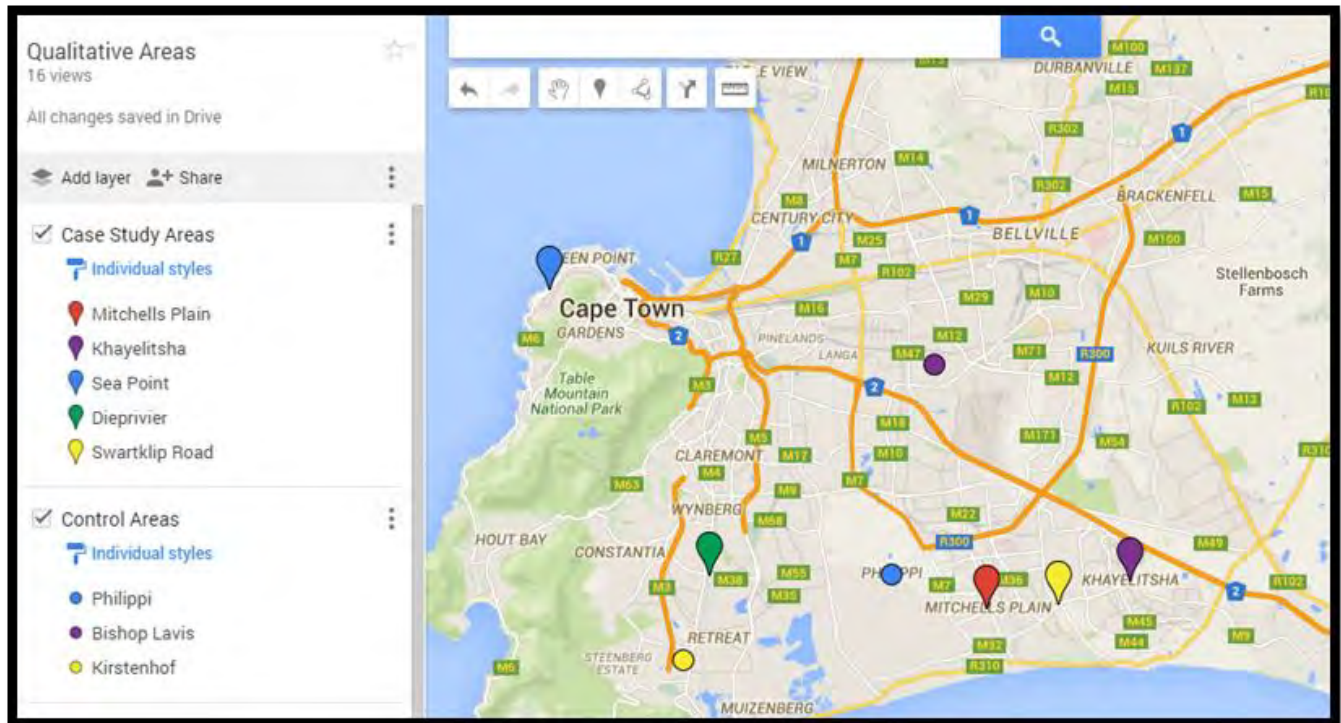


Figure 30: Locations of Case Study and Control Areas shown with Markers<sup>12</sup>

<sup>11</sup> Best and worst control areas highlighted in green and red respectively.

The types of facilities were described with a combination of the following categories of improvement:

- Cycle and pedestrian ways (both upgrades and new construction),
- improved Universal Access intersection design,
- landscaping,
- street furniture,
- dignified urban spaces,
- circle and intersection design.

These were the descriptions of the NMT facility improvements that had been implemented. The focus of the assessments were to determine how effectively these design aspects had been implemented.

### 6.1.2 STEP 2: DRAFTING OF CASE STUDY INFRASTRUCTURE ASSESSMENT RUBRIC

The recently revised NMT Facility Guidelines (NDoT, 2015) was used as the foundation for the case study infrastructure assessment criteria. The rubric that was developed from the NMT Facility Guidelines (NDoT, 2015) is presented in Table 14. Each principle was described in five levels of implementation. A rating of one would indicate that the principle is completely lacking from the area. A rating of three would indicate that some evidence of the principle could be seen but that it is not sufficient enough to make a significant impact. Ratings of four and five indicate that the principle is clearly evident and is likely to be having a significant impact on the quality of the trip for the NMT users.

In terms of results, an average success rating of between 80% and 100% indicate that the principles are adequately applied. An average rating between 60% and 79% indicate that the principles have been applied with limited levels of success. While a rating of 59% and below, indicate that the principles have been scarcely applied are unlikely to generate the impact that is required to improve NMT facilities in urban areas of South Africa.

### 6.1.3 STEP 3: GATHERING OF IMAGES OF ROUTES

In this step, various images were gathered from Google Maps Street-view that could then be used to rate the routes against the various principles and guidelines (Table 14). Images were selected that were able to highlight several aspects of NMT implementation that were typical within that NMT facility implementation. These aspects may be positive or negative as long as they demonstrated the principles that were outlined in the rubric (Table 14) and the number of aspects discussed per site varied. Thus, the ratings were based on overall view of the whole NMT facility.

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<sup>12</sup> Generated using Google maps: <https://www.google.co.za/maps/@-33.9930304,18.4673571,12z/data=!4m2!6m1!1szKJnhJUgWxR4.kxbauye9ubIs?hl=en>, December 2015.

Principles and recommendations	Rating: 1 Not evident	Rating: 2 Not adequate at all	Rating: 3 Sub-adequate	Rating: 4 Adequate	Rating: 5 Best practice
<b>Evidence of completeness of network</b> (Chapter 3.2.4, page 24)	Physical or traffic barriers that prevent further movement	No evidence of connections to other links at the ends of the route	Partially connected NMT facilities on one side of the route	Partially connected NMT facilities on both ends of route	Fully connected NMT facilities on both ends of route
<b>Evidence of directness</b> (Chapter 3.2.4, page 24)	NMT routes are longer than motorised transport routes with multiple barriers	NMT routes are longer than motorised transport routes. Several barriers and limited NMT facilities at crossing points	NMT routes are same distance as motorised transport routes. Several barriers and limited NMT facilities at crossing points	NMT routes are same distance as motorised transport routes. Few barriers and some NMT facilities at crossing points	NMT routes are shorter distances than motorised transport routes. No barriers and NMT facilities at crossing points
<b>Evidence of less conflict</b> (Chapter 3.2.4, page 24)	No clear path for NMT user at intersections and several obstacles for NMT users to navigate. Several conflict points between NMT users and motorised transport	Limited paths for NMT users to navigate intersections. Several conflicts between NMT users and motorised transport and several barriers / obstacles	Some evidence of paths for NMT users to navigate intersections. Several conflicts between NMT users and motorised transport and several barriers / obstacles	Defined path for NMT users to navigate intersections. Few conflicts between NMT users and motorised transport and few barriers / obstacles	Clear, well defined path for NMT users to navigate intersections. No conflicts between NMT users and motorised transport and no barriers / obstacles
<b>Evidence of speed appropriateness</b> (Chapter 3.2.4, page 24)	No NMT facilities and no traffic calming measures to reduce the speeds of motorised traffic	No NMT facilities and limited traffic calming measures to reduce the speeds of motorised traffic	No separated NMT facilities with limited traffic calming measures to reduce the speeds of motorised traffic	Partially separated NMT facilities with traffic calming measures to reduce the speeds of motorised traffic	Fully separated NMT facilities with traffic calming measures to reduce the speeds of motorised traffic
<b>Evidence of attractiveness</b> (Chapter 3.2.4, page 25)	Unattractive urban environment with no waste bins and no street furniture	Urban environment that is poorly maintained, with limited waste bins and but no other appropriate street furniture	Green environment that is partially maintained, with limited waste bins and other appropriate street furniture	Attractive green environment that is partially maintained, with some waste bins and other appropriate street furniture	Attractive green environment that is well maintained, with adequate waste bins and other appropriate street furniture
<b>Evidence of reduced barriers</b> (Chapter 3.2.4, page 25)	NMT routes are along difficult terrain with sudden and frequent changes in direction. No tolerance of errors of NMT users	NMT routes are along somewhat difficult terrain with sudden and frequent changes in direction. Limited tolerance of errors of NMT users	NMT routes are along typical terrain with sudden and frequent changes in direction. Limited tolerance of errors of NMT users	NMT routes are along short, level terrain with limited sudden changes in direction. Some tolerance of errors of NMT users	NMT routes are along short, level terrain with sudden changes in direction. Reasonable amount of tolerance of errors of NMT users
<b>Evidence of safety aspects</b> (Chapter 3.2.4, page 26)	Route has several blind corners and places for concealment. No alternative routes for NMT users. Inadequate lighting provided	Route has several blind corners and places for concealment. No alternative routes for NMT users. Inadequate street lighting.	Route has some blind corners and some places for concealment. There are few alternative routes for NMT users. Adequate street lighting.	Route has limited blind corners and limited places for concealment. There are alternative routes for NMT users. Adequate street lighting.	Route has no blind corners and no places for concealment. Several alternative routes for NMT users. Adequate street lighting.

Table 14: Infrastructure Assessment Ratings for Non-Motorised Transport Facilities

#### 6.1.4 STEP 4: RATINGS OF NON-MOTORISED TRANSPORT FACILITIES ON SELECTED ROUTES

Using the rubric and the images from the previous two steps, the selected routes were assigned ratings from 1 to 5. A higher score indicates a more successful NMT facility implementation while a lower score indicates that NMT users are not being adequately catered for. The final ratings are presented in Table 15.

Table 15: Resulting Ratings of the Selected Routes in the Case Study and Control Areas

	Case Study Facilities Implemented				Control Areas Existing Facilities		
NMT Facility Guidelines: Principles and recommendations	Mitchells Plain	Dieprivier	Khayelitsha	Sea Point	Philippi	Bishop Lavis	Kirstenhof
Evidence of completeness of network	4	3	4	3	2	4	3
Evidence of directness	3	3	3	3	3	3	3
Evidence of less conflict	3	3	5	4	2	3	4
Evidence of speed appropriateness	4	3	4	4	2	4	4
Evidence of attractiveness	4	3	4	5	2	4	4
Evidence of reduced barriers	3	3	4	4	2	3	4
Evidence of safety aspects	4	4	4	3	2	4	3
Total per facilities	25	22	28	26	15	22	25
Average	72.14%				55%		

It is important to note that when calculating the averages for the different principles within the control areas, the score of Philippi was weighted twice as it was used for both the cyclist and pedestrian needs. The detailed analyses of how these ratings were allocated are now discussed per area. The case study areas are first discussed, followed by the control areas.



#### 6.1.4.1 CASE STUDY AREAS

The detailed analysis of the best and worst performing case study areas for pedestrians and cyclists are now presented.

#### 6.1.4.1.1 MITCHELLS PLAIN: BEST PERFORMING PEDESTRIAN EQUIVALENT ACCIDENT NUMBERS

The NMT facility implementations were along two routes, as shown in Figure 31. The implementations seemed to focus more on the needs of pedestrians than those of cyclists. This will be discussed using screenshots collected from Google Maps.

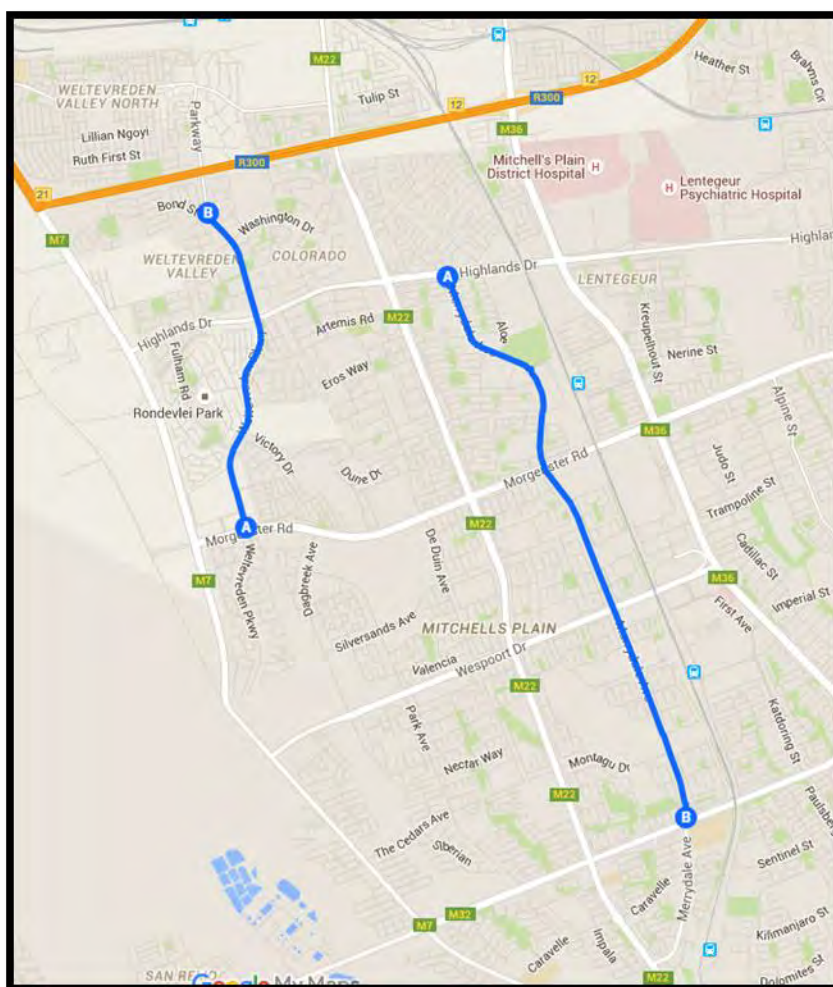


Figure 31: Mitchells Plain Non-Motorised Transport Facilities (Source: Google Maps)





Figure 32: Weltevreden Parkway Infrastructure Assessment (Source: Google Maps)

In Figure 32 there are well constructed pedestrian sidewalks, indicated with a green circle. However, there are no cycling facilities. These could be easily added considering the ample space on both sides of the road. Despite the sidewalks being recently implemented, there is poor placement of the street lamppost, which is positioned in the centre of the walkway, indicated by the red circle.

Therefore, from Figure 32, ratings for the following principles were given:

- Evidence of completeness of network: 4
- Evidence of less conflict: 3
- Evidence of directness: 3
- Evidence of reduced barriers: 3

The second route in that had been selected in this area was Merrydale Ave. The remaining principles will be analysed in Figure 33.



Figure 33: Merrydale Ave Infrastructure Assessment (Source: Google Maps)

The location of Figure 33 was near to a school, therefore, speed appropriate designs and safety aspects would be considered of critical importance here as there would be a higher concentration of vulnerable NMT users (namely children).

In Figure 33 several positive aspects were seen. Firstly, the area was dignified and had elements of good landscaping features. The pedestrian crossing is integrated with paths on the sidewalks, which is highlighted in the lower green circle. Additionally, there are road markings and road signs to draw attention to the nearby school, thereby increasing the level of safety of the area. There is also integration with public transport services with the loading bay, bus shelter and waste bin provided for these users. This is highlighted in the top green circle. Therefore, the following ratings were given for the remaining principles in this area:

- Evidence of speed appropriateness: 4
- Evidence of attractiveness: 4
- Evidence of safety aspects: 4

The NMT implementations along this route were successful but could be improved further with more attention to detail, as well as providing clear connected routes for cyclists.

#### 6.1.4.1.2 DIEPRIVIER: WORST PERFORMING PEDESTRIAN EQUIVALENT ACCIDENT NUMBERS

NMT facilities that were implemented along this route aimed to cater for both pedestrian and cyclist users, shown in Figure 34. However, as seen in Figure 35 and Figure 36, this was not always successful or effective.

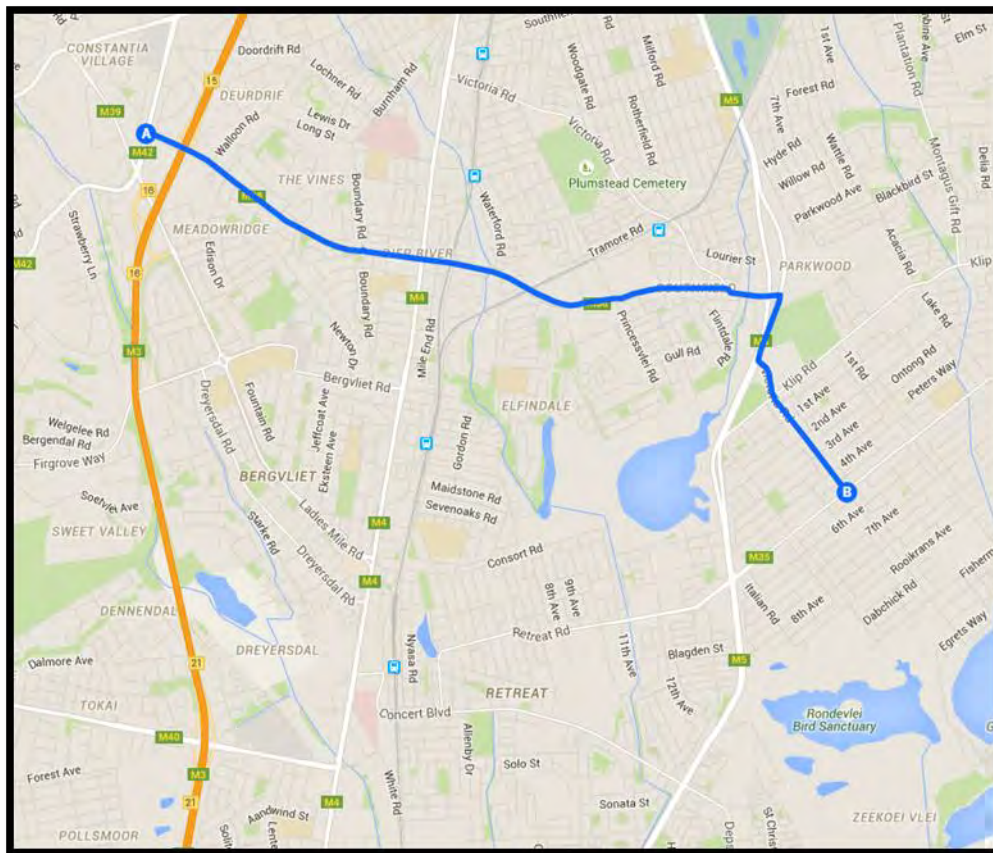


Figure 34: Dieprivier Non-Motorised Transport Facilities (Source: Google Maps)

In Figure 35, the positive aspect that is highlighted is the fact that the NMT facility is grade separated from the motorised traffic. This is an important aspect of improving the safety of NMT users. The negative aspect that is highlighted by the red circles are poorly placed lamp posts which form movement barriers for the NMT users on the facility. From this, the following ratings were given:

- Evidence of reduced barriers: 3
- Evidence of safety aspects: 4
- Evidence of speed appropriateness: 3.



Figure 35: M38 Infrastructure Assessment (Source: Google Maps)

In Figure 36, more negative aspects of the NMT facilities are noted. These include additional movement barriers such as sign posts in the middle of the NMT facility, as well as impractical space assigned to the cyclist path. If the older picture of the areas shown in the top left corner of Figure 36 is compared to the existing facility, no additional advantage can be seen, in terms of space allocation to NMT users. Additionally, with the sign for NMT users being placed in the middle of the sidewalk, the route actually has an additional physical barrier.

From Figure 36, the limited space allocated to cyclists means that cyclists will most likely prefer to cycle on the road with the motorised traffic. Therefore, the following rating was given:

- Evidence of less conflict: 3.





Figure 36: M38 Infrastructure Assessment (Source: Google Maps)

However, in Figure 37, the signpost for the NMT facility is placed in an appropriate position and there is green vegetation, which increases the level of attractiveness of the route. While the signpost is not creating a movement barrier, the two concrete bollards do create movement barriers, while the value that they add seems questionable.



Figure 37: M38 Infrastructure Assessment (Source: Google Maps)

Therefore, combining what had been seen in previous images and that of Figure 37, the following ratings were given:

- Evidence of attractiveness: 3
- Evidence of completeness of network: 3
- Evidence of directness: 3.

#### 6.1.4.1.3 KHAYELITSHA: BEST PERFORMING CYCLIST EQUIVALENT ACCIDENT NUMBERS

The routes that were investigated in this case study area are shown in Figure 38. From the quantitative analysis this area had the largest relative improvements for cyclists out of all the case study areas, the improvements for pedestrian EANs were proportionally smaller but still significant. However, Mitchell's Plain had the largest relative improvement for pedestrian EANs and, therefore, that case study area was selected for the case study infrastructure assessment for the best performing pedestrian area. With this in mind the NMT facilities are assessed.

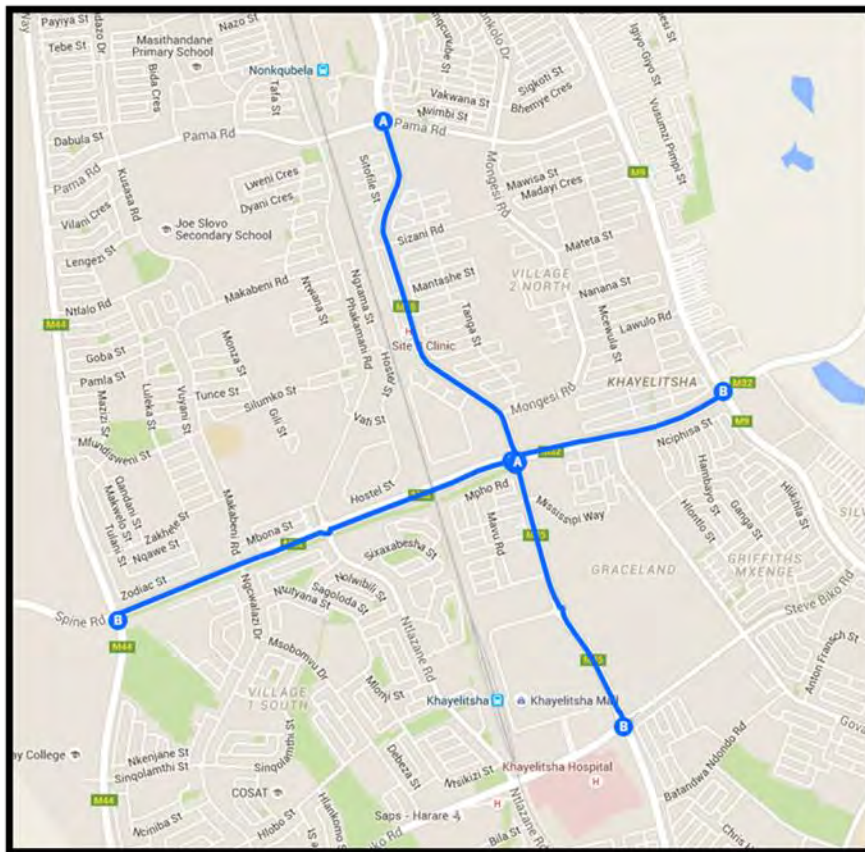


Figure 38: Khayelitsha Non-Motorised Transport Facilities (Source: Google Maps)



The first image that is presented in Figure 39 shows two positive aspects. This is firstly the clear focus of the NMT facility implementation to improve the quality of the NMT environment by increasing the levels of attractiveness, which is highlighted in the green right hand-side circle. The green circle on the left hand-side of Figure 39 highlights that adequate space has been provided for pedestrians waiting for public transport. Additionally, there is sufficient space to walk along the route. The negative aspect that is highlighted by the red circle is the lack of dedicated cycling paths or space allocated for cyclists. However, having said this, the improvements that can be seen in this figure do have benefits for both pedestrians and cyclists. Furthermore, as seen in later images, separate cycling paths are provided in other sections of the route.



Figure 39: Spine Road Infrastructure Assessment (Source: Google Maps)

It should be noted that while, this has had a significant improvement for the cyclists in the area, it could be improved further by the consistent implementation of facilities for cyclists to ensure not only the safety of cyclists improves, which has been already demonstrated from the existing data, but also to improve the efficiency of cycling trips improves as one dedicated cycling path leads clearly into the next cycling path. This, therefore, improves the cycling trip by making the links continuous and seamless.



From this the following ratings were given:

- Evidence of attractiveness: 4
- Evidence of safety aspects: 4
- Evidence of reduced barriers: 4
- Evidence of less conflict: 4

In the next image, shown in Figure 40, shows the consistency of good quality NMT facilities, which helps to create an environment in which the behaviour of all road users becomes more predictable and, therefore, safety improves. Additionally, the consistency of implementation also helps to improve the attractiveness and reduce unnecessary movement barriers of NMT users. The top green circle highlights good landscaping and clear lines of sights for pedestrians as well as good paving used for the facility. The lower green circle highlights the implementation of pedestrian islands that assist pedestrians to cross the motorised traffic comfortably and with less fear for their safety as the distance can be crossed in two phases. Additionally, the intersection is a circle design which is also noted to have traffic calming effects on motorised traffic in the NMT Facility Guidelines (NDoT, 2015).



Figure 40: Spine Road Infrastructure Assessment (Source: Google Maps)

The same approach and designs were applied to the other route of M45. The consistency in this area of NMT facilities adds considerable quality to NMT trips as users move from one section to another section seamlessly. This can be seen with the same NMT facility designs being implemented, as shown in Figure 41.



Figure 41: M45 Infrastructure Assessment (Source: Google Maps)

Additionally, both cyclist and pedestrian routes were grade separated and often separated even further from motorised traffic with landscaping features. This can be seen in Figure 42.



Figure 42: M45 Infrastructure Assessment (Source: Google Maps)

From these aspects, the following ratings were given for the various principles:

- Evidence of completeness of network: 4
- Evidence of directness: 3
- Evidence of speed appropriateness: 4

Having grade separated cycling facilities may be a critical component of the reducing cyclist EANs seen in the quantitative investigations.

#### 6.1.4.1.4 SEA POINT: WORST PERFORMING CYCLIST EQUIVALENT ACCIDENT NUMBERS

The facility implementation investigated here is noticeably short, as shown in Figure 43, but of a very high quality. It is however an isolated stretch of NMT facility that from the quantitative investigation did not have a significant impact on the safety of NMT users in the area as a whole.

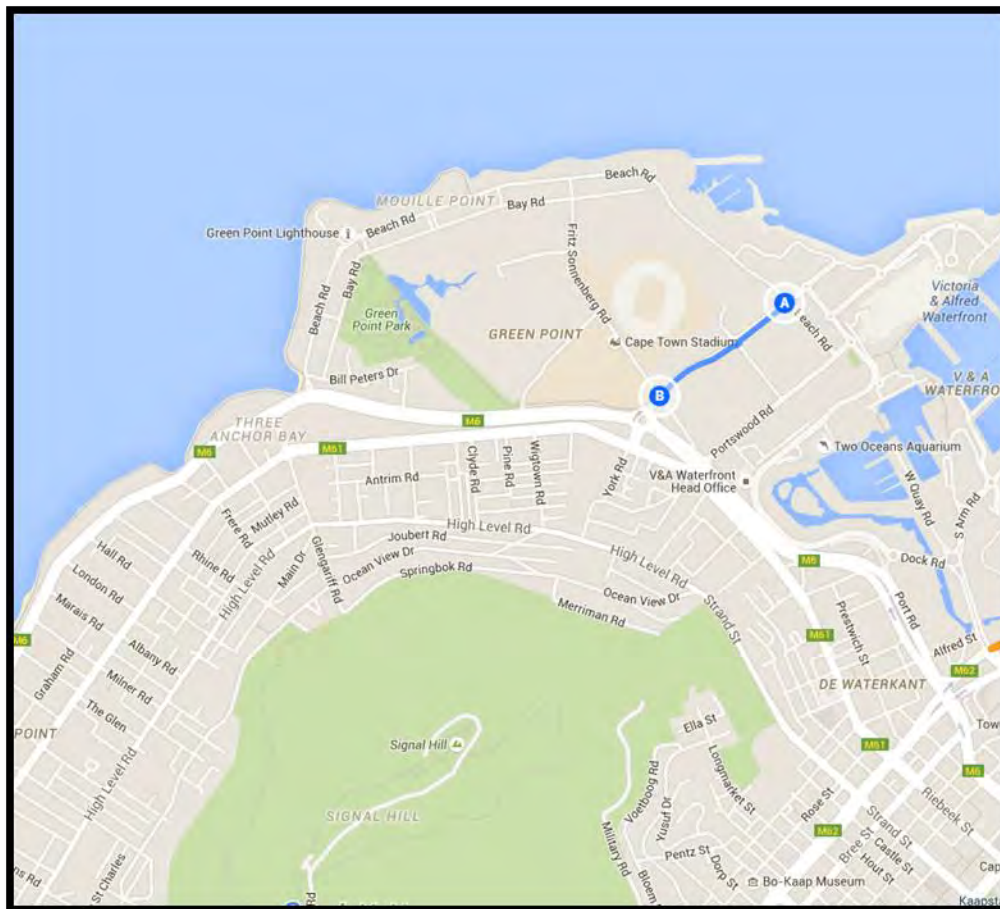


Figure 43: Sea Point Non-Motorised Transport Facilities (Source: Google Maps)

The nearby stadium had a major influence on the space allocated to pedestrian users. Additionally, considerable effort went into creating a green attractive environment, which was not often seen on the other routes. In Figure 44, several positive aspects are highlighted.





Figure 44: Sea Point Infrastructure Assessment (Source: Google Maps)

The left hand-side green circle highlights pedestrian islands that help create an environment that is not overwhelming for pedestrians as lanes of traffic are separated. The centre green circle highlights the extensive landscaping throughout the route, which is well-maintained, while the right hand-side circle draws attention to the spacious space allocated to pedestrians. From these aspects the following ratings were given:

- Evidence of safety aspects: 4
- Evidence of attractiveness: 5
- Evidence of speed appropriateness: 4
- Evidence of reduced barriers: 4

However, while these aspects did well, the practicality for cyclists on this route is questionable. This can be seen in the following Figure 45.



Figure 45: Sea Point Infrastructure Assessment (Source: Google Maps)

Despite large amounts of space being available to NMT users a separated, convenient, useable facility for cyclists was not implemented. Evidence of inappropriate or inadequate facilities for cyclists is shown in the red circle where the cyclist is using the motorised section of the route. A key element of implementing better NMT facilities is that the facilities should be simple and well integrated with other links for a particular NMT users. Therefore, in this situation the links for cyclists do not exist or are not as well implemented to encourage cyclists to use separated NMT facilities. Thus resulting in the cyclist choosing or being forced to join the motorised traffic. However, for pedestrians, the network seems to be more complete as the pedestrian routes continue on either side of the route. Thus, for pedestrians (the majority NMT user in on this route), there is improved separation and therefore less conflict between pedestrians and motorised traffic. Based on this, the following ratings were given:

- Evidence of completeness of network: 3
- Evidence of directness: 3
- Evidence of less conflict: 3



One of the important lessons that could be taken from this case study area is that while NMT implementations can dramatically improve areas, if the needs of one particular NMT user (in this case cyclists) are not catered for, then the overall affect could still be negative. In this particular case, the lack of safe routes for cyclists is likely to be a major challenge facing the cyclists in this area. Furthermore, the isolated nature of the NMT facility implementations is more likely to have negative impacts on cyclists as they tend to have longer trips covering more distance. This could be something to be considered in future upgrades in the Sea Point area. In the next section the control areas are investigated.

#### 6.1.4.2 CONTROL AREAS

In the control areas, older NMT designs were seen as well as a lack of NMT facilities or disjointed provision of NMT facilities. The first control area, Philippi, that follows, had the worst performing EANs for both pedestrians and cyclists. The best performing pedestrian area, Bishop Lavis, will be discussed next, followed by the best performing cyclist control area (Kirstenhof).

##### 6.1.4.2.1 PHILIPPI: WORST PERFORMING PEDESTRIAN AND CYCLIST EQUIVALENT ACCIDENT NUMBERS

The selected route in this control area was selected as shown in Figure 46. This route was selected as Spine Road had been improved in the Khayelitsha area and, therefore, these would be the facilities that NMT users would feed into if they continued along Spine Road.

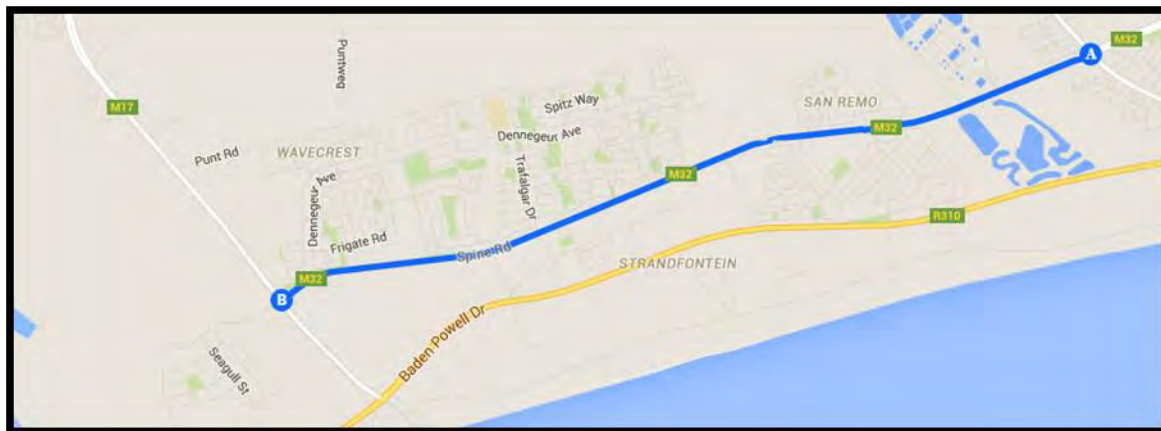


Figure 46: Philippi with Selected Route (Source: Google Maps)

From Figure 47, there are clear desire lines of NMT users marked out in the vegetation. Despite generous amounts of space allocated to motorised traffic, few paved surfaces are provided for NMT users along this route. Most of the space that is used by NMT users is poorly maintained and has physical barriers throughout. These physical barriers include poorly placed signposts, lampposts, waste, and a lack of drop kerbs.



Figure 47: Philippi Infrastructure Assessment (Source: Google Maps)

Features that are highlighted in Figure 47 with red circles include the following (from left to right):

- No space provided for cyclists, travelling along this route.
- Clear pedestrian desire lines<sup>13</sup> indicate that a crossing facility should be provided here, to accommodate pedestrians going to the bus shelter.
- No drop kerbs to enhance pedestrian or cyclist movements.

Therefore, based on these observations, the following ratings were given:

- Evidence of completeness of network: 2
- Evidence of directness: 3
- Evidence of less conflict: 2
- Evidence of speed appropriateness: 2
- Evidence of attractiveness: 2
- Evidence of reduced barriers: 2

<sup>13</sup> Line of travel that represents the shortest or most easily navigated route (Kohlstedt, 2016)

- Evidence of safety aspects: 2

In the next area, the selected route links a public transport station with the main roads in the area and through to a local school.

#### 6.1.4.2.2 BISHOP LAVIS: BEST PERFORMING PEDESTRIAN EQUIVALENT ACCIDENT NUMBERS

This area demonstrated the best improvements of pedestrian EANs out of all of the control areas. The route that was selected linked a public transport station to a nearby main road and then through to a local school. This is shown in Figure 48.

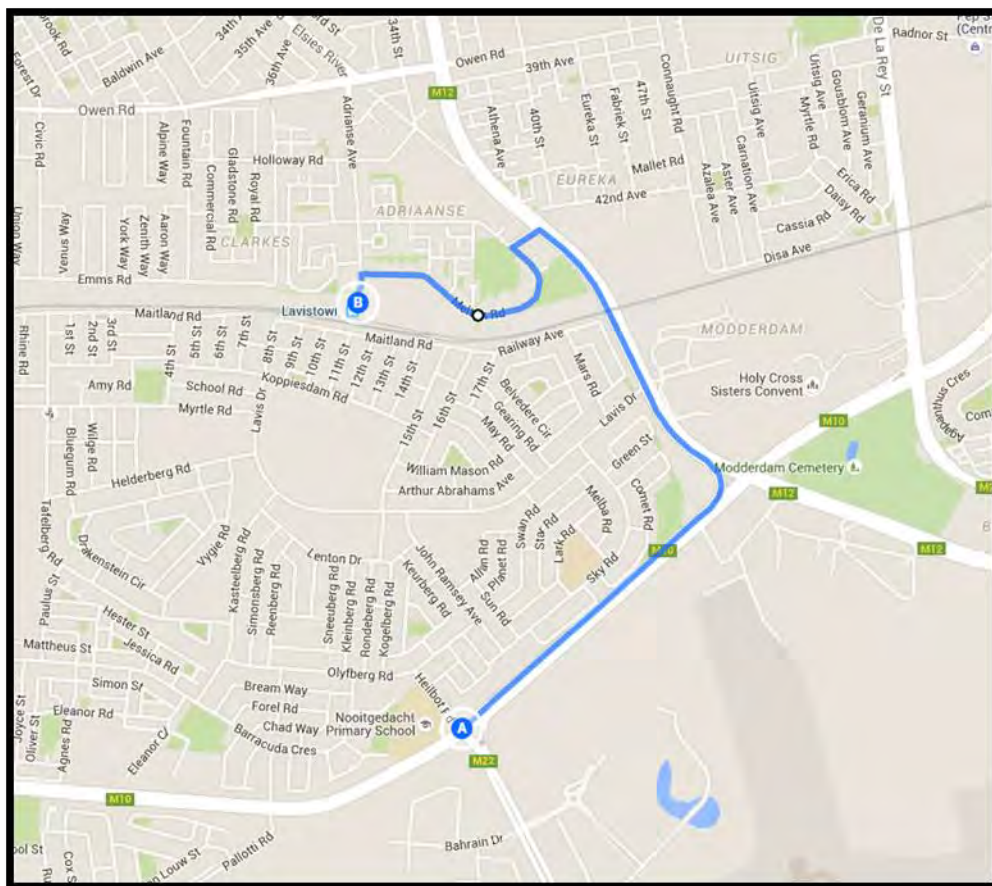


Figure 48: Bishop Lavis with Selected Roads (Source: Google Maps)

When viewing this route it is evident that the NMT facilities, namely facilities for pedestrians, are of a good quality. This can be seen in Figure 49, where there is evidence of good landscaping, sufficient space allocation to pedestrians and signalised pedestrian crossings.



Figure 49: Intersection of M10 and Heilbot Road Infrastructure Assessment (Source: Google Maps)

Therefore, the following ratings were assigned:

- Evidence of completeness of network: 4
- Evidence of directness: 3
- Evidence of less conflict: 3
- Evidence of speed appropriateness: 4
- Evidence of attractiveness: 4

In the next location along the route, evidence of traffic calming can be seen on lower order roads leading towards the public transport station. This can be seen in Figure 50.





Figure 50: Melton Road Infrastructure Assessment (Source: Google Maps)

From Figure 49 and Figure 50, the following ratings were given:

- Evidence of reduced barriers: 3
- Evidence of safety aspects: 4

While, there is room for improvement, especially regarding the needs of cyclists in the area, the facilities available for pedestrians are considerably better than what was seen in Philippi.

#### 6.1.4.2.3 KIRSTENHOF: BEST PERFORMING CYCLIST EQUIVALENT ACCIDENT NUMBERS

In this control area, the selected route started at a local shopping centre and ended with the roads around the local school. Thus local collector roads (smaller roads), as well as arterial roads (main roads) were investigated. The route is shown in Figure 51.

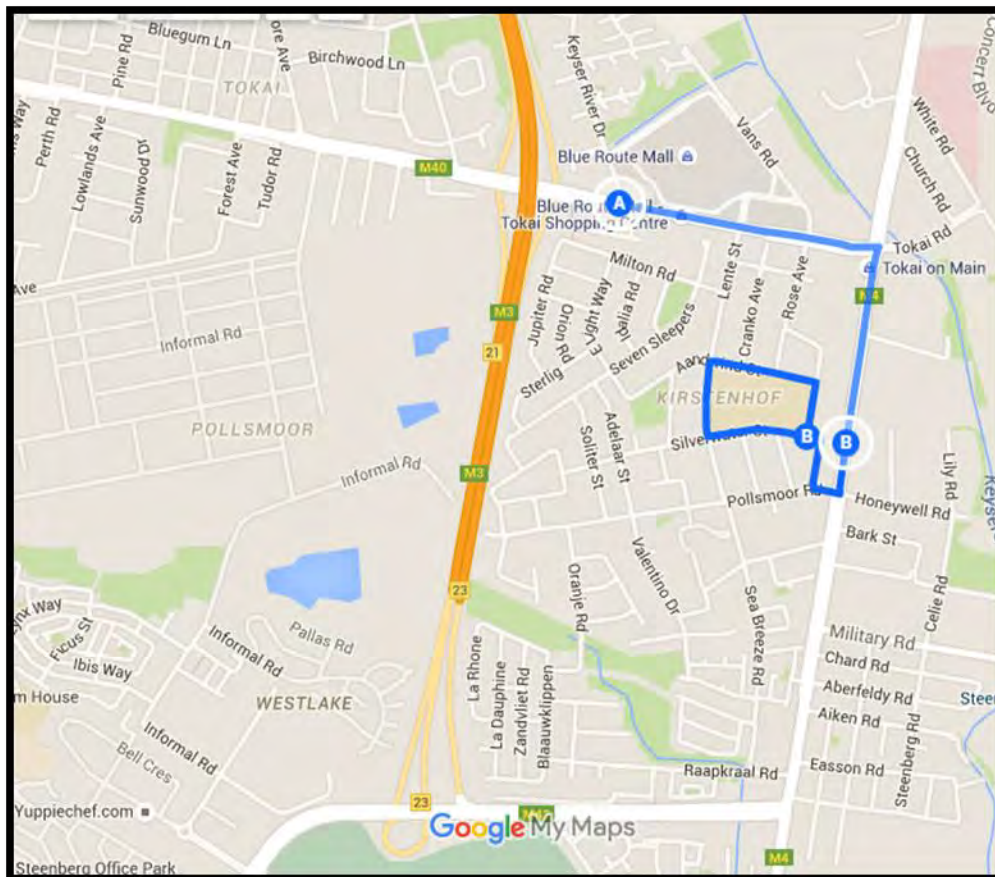


Figure 51: Kirstenhof with Selected Roads (Google Maps)

On the arterial roads, there were clearly defined pedestrian facilities on either side of the motorised traffic. Additional features include pedestrian islands, refugee islands, improved lane markings, landscaping and signalised crossings. These features can be seen in Figure 52 and Figure 53.





Figure 52: Tokai Road Infrastructure Assessment<sup>14</sup> (Source: Google Maps)

In Figure 52, the green circle on the left of the image highlights the Refuge Island / Pedestrian Island. The green circle on the right hand side highlights a good quality pedestrian sidewalk with a landscaping feature. Refuge islands were also used at intersections as a traffic calming measure as well as to assist pedestrians in crossing the intersection, as shown in Figure 53.



Figure 53: Tokai Road at an Intersection<sup>15</sup> Infrastructure Assessment (Google Maps)

<sup>14</sup> Previous image of the site shown in top left-hand corner

<sup>15</sup> Older available image of intersection shown in top left hand box

In the next image, a typical example of the collector roads is shown in Figure 54.



Figure 54: Typical Roads surround the School Infrastructure Assessment (Google Maps)

While the surrounding environment is attractive and green (highlighted by the green circle), the sidewalks are not practical for pedestrians. Apart from having several obstacles in place, the sidewalks are unpaved, which would result in muddy conditions during wet weather. The result of these conditions is that pedestrians are unlikely to walk on the sidewalks. This is seen in Figure 54, highlighted by the red circle.

From the images collected, the following ratings were assigned:

- Evidence of completeness of network: 3
- Evidence of directness: 3
- Evidence of less conflict: 4
- Evidence of speed appropriateness: 4
- Evidence of attractiveness: 4
- Evidence of reduced barriers: 4
- Evidence of safety aspects: 3

The improvements to the arterial roads in the Kirstenhof area are more likely to have contributed to the reduction of EANs of cyclists than the characteristics of the collector roads.

## 6.2 CASE STUDY INFRASTRUCTURE ASSESSMENT FINDINGS AND DISCUSSION

From the rating of the selected routes in the case study areas and the control areas, it could be seen that there is significant room for improvement in all areas. The case study areas did perform better than the control areas with an infrastructure assessment advantage of 17.14%. However, some insight into which principles are generally being implemented better than others can be gained by comparing average scores per principle. This can be seen in Table 16.

Table 16: Average Scores per Principle for Case Study and Control Routes

	Case Study Routes: average per Principle	Control Routes: average per Principle
Evidence of Completeness of Network	3.5	2.75
Evidence of Directness	3	3
Evidence of less Conflict	3.75	2.75
Evidence of Speed Appropriateness	3.75	3
Evidence of Attractiveness	4	3
Evidence of reduced Barriers	3.5	2.75
Evidence of Safety Aspects	3.75	2.75

The control routes proved to average between 2.75 and 3 for all of the principles, indicating that none of the principles are well implemented in the old existing road network. The NMT facility implementations in the case study areas did improve the level of attractiveness for NMT users the most out of all the principles. However, the NMT facility implementations can be seen to be failing to provide shorter, more direct routes for NMT users. This is an important aspect as this would reduce the amount of physical energy and time significant for NMT users. If routes are improved in this manner it may have a significant impact on the number of NMT trips, as they become more attractive and more efficient. Based on these findings, as well as the findings from the assessments, a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis of the NMT facilities was drafted. This helps to consolidate the various findings of this research and provide suggestions on how best to improve the roll out of NMT facilities and implementations in Cape Town.

### 6.2.1 SWOT ANALYSIS OF INVESTIGATIONS: STRENGTHS

The strengths of the NMT facility implementations are highlighted and summarised in the following bullet points.

- In areas that NMT facility implementations have occurred, the safety of NMT users has improved significantly (based on quantitative investigations).
- In the case study TAZ areas, there were greater percentage increases in the number of walking trips than the control areas. This was also the true when comparing the percentage changes of walking trips within the case study TAZs to provincial and national changes in the number of walking trips.
- NMT facility implementations are generally improving the facilities that are available to NMT users. This is helping to create better urban spaces for NMT users to move within.
- The basic ways to address concerns of NMT users are incorporated into some of the NMT facility implementation. These practices need to be improved upon, as newer, better designs and practices have been developed since and are available and can be readily implemented.
- For some sections of facilities that were implemented, the standard of implementation was very high. This indicates that high quality NMT facilities are well within the capabilities of South African practitioners. However, this needs to be encouraged as other NMT facilities that implementations were rather poor.

### 6.2.2 SWOT ANALYSIS OF INVESTIGATIONS: WEAKNESSES

The weaknesses of the NMT facility implementations are highlighted and summarised in the following bullet points.

- The NMT facility implementations are not addressing the needs of NMT users. One way in which the current NMT facilities are failing is by not providing routes that are shorter and more direct than motorised transport routes.
- The NMT facilities did not have a noticeable impact on the volumes of cycling trips, this may be due to the disconnected cycling facilities that currently seen.
- In many of the images for the case study infrastructure assessments there were indications of poor implementation. These include complete lack of drop kerbs or poorly implemented drop kerbs for NMT users, which would create movement barriers. Additionally, other barriers such as street furniture (dustbins, lampposts, signs) were poorly placed and reduced the quality of the NMT implementations. Additionally, adequate space is not being assigned to NMT users, with existing NMT facilities often just being divided with paint for pedestrian and cyclist users. Without reclaiming more road space for NMT users, motorised traffic will continue to dominate public transport spaces, leaving NMT users as second-class commuters.
- The current implementations are disjointed and are often isolated from the rest of the NMT network, resulting in facilities that are not practical in terms of improving the quality of the



NMT trip for the user. Links that the NMT user has to use before or after the NMT facility implementation may have significant hindering factors. These may discourage the user from making the trip in the first place.

- In some of the areas, there was clear evidence of inadequate maintenance with vegetation and waste dominating the sidewalks and other NMT facilities. If this is not addressed and properly managed then it is unlikely that the NMT facilities will have the optimal impact.

### 6.2.3 SWOT ANALYSIS OF INVESTIGATIONS: OPPORTUNITIES

The opportunities of the NMT facility implementations are highlighted and summarised in the following bullet points.

- Better integration with public transport and places of education and work could greatly improve NMT trips. However, stakeholders and projects of public transportation would need to co-ordinate and collaborate with NMT leaders to improve the integration between NMT facilities and public transportation facilities.
- Using the NMT Facility Guidelines would improve the prioritisation and quality of the designs of NMT facilities in urban areas of South Africa. The guidelines provide a clear approach to develop much improved designs and implementations of NMT facilities.
- By focusing on incorporating the principles that were used in the case study infrastructure assessments, NMT facility implementations are likely to make meaningful contributions to improving NMT facilities in urban areas of South Africa.

### 6.2.4 SWOT ANALYSIS OF INVESTIGATIONS: THREATS

The threats of the NMT facility implementations are highlighted and summarised in the following bullet points.

- While NMT facility implementations do seem to be addressing the safety issues in most of the case study areas, there is limited evidence in the case study infrastructure assessments to indicate that the implementations are addressing the security concerns for NMT users. The case study infrastructure assessments showed that very few design elements regarding security had been added or were present. Some examples of design elements that would help improve the security of the routes include surveillance cameras, the creation of gathering places for NMT users along the routes (parks, informal trading areas, shaded areas) and the removal of barriers to ensure free movement and clear lines of sight around and through areas.
- The NMT facilities have had a smaller positive impact on the cyclist EANs than the impact seen with regards to the pedestrians. Additionally, in the investigation of the cycle trips, the evidence also suggests that the NMT facilities are failing to meet the needs of cyclists in urban areas of South Africa. Steps should be taken to ensure that future cycling facilities are better designed, implemented and maintained to ensure the maximum benefit to the NMT users and that resources and efforts are not wasted.

- Building awareness around the NMT facility guidelines, and encouraging practitioners and stakeholders to use the guidelines in their projects and designs, would need sufficient training, education and perhaps incentives. It will take dedicated resources to achieve this. If this does not happen it is unlikely that the quality of the NMT facilities that are being rolled out will improve. This may result in sub-optimal results been demonstrated, which could incorrectly be viewed as NMT facilities not being an effective means of improving NMT in urban areas of South Africa.



## 7. CONCLUSIONS

The benefits of NMT, as a mode of transport in urban areas of South Africa could contribute greatly to the transportation network and urban environment. However, there are challenges of providing for NMT users in urban areas of South Africa, so that they are able to make NMT trips in a safe and comfortable manner. The aim of this research was to investigate the impact that providing NMT facilities had in addressing some of these identified challenges. These challenges were mainly concerned with the safety of NMT users, the number of NMT trips and the quality of the NMT facilities in urban areas of South Africa. Several research questions were drafted and through a series of investigations, these research questions were addressed. The conclusions to all the research questions of each proposition are now briefly concluded.

### 7.1 SUMMARY OF PROPOSITION 1

“IN CAPE TOWN THERE HAS BEEN AN INCREASE IN THE IMPROVEMENTS OF NMT FACILITIES OVER THE YEARS”

Considering the emphasis placed on NMT, as a mode of transport in the transportation policy and strategy documents, an increase in the quality and number of NMT facility improvement was expected. While the NMT Facility Guidelines were not available for the NMT facilities that were investigated in this research, it does indicate that efforts had already been made before the completion of the revised NMT Facility Guidelines.

Therefore, for this research, the type of NMT facilities in Cape Town needed to be investigated and established. Then the consequences of the approaches that have been adopted in Cape Town could be elaborated upon, so that potential improved approaches and practices could be recommended. This would be done in alignment with the recently updated NMT Facility Guidelines (NDoT, 2015). The implementations that were investigated were complete before the NMT Facilities were drafted and therefore the quality of NMT facilities needed to be determined. Therefore, before investigating the effects of NMT facility implementations, an understanding of where and what had been done needed to be established. Developing an understanding of the implementations aids in the identification of the various approaches or characteristics of how the improvements have been rolled out and how they may have positively or negatively affected the success of NMT facility implementations.

Three research questions were formulated from the aforementioned proposition. The questions and the findings that pertain to each question are summarised and presented in the succeeding sections.

#### **1. Where and what type of NMT facilities and implementations have been rolled out?**

Using Cape Town as a case study area, the locations of NMT facilities were spread throughout the Cape Town area (Appendix A), with many of the NMT facility implementations being isolated from other NMT facility implementations. While the adopted strategy has meant that more areas received

improvements, it also has meant that the NMT network is likely to remain fragmented for a longer period of time before the different NMT implementations begin to link together. Considering that NMT users are likely to be deterred by one section of a trip that is problematic, more focus should be placed on improving the connectivity of the NMT network (Pretorius, 2015) than the range of the network. As there are limited financial resources for the development of NMT facilities in Cape Town, as well as the rest of urban areas of South Africa, the NMT network is unlikely to become more integrated by coincidence or by a high volume of implementations. Rather, it will achieve this through a more effective implementation strategy that actively integrates NMT facilities and links.

The nature of what was implemented depended slightly on the local context. However, the NMT facility implementations generally aimed to improve pedestrian and cycling paths. Furthermore, the urban environments were improved through landscaping features, improved intersections and applying principles of Universal Access to the designs. The success of these implementations were more dominant for pedestrians than for cyclists which demonstrated smaller levels of success, as can be seen in the answer to the next research question.

## **2. Are these facilities adequately designed and implemented to serve the safety and usage requirements of the people who use them?**

From the quantitative investigations of the Equivalent Accident Numbers of pedestrians and cyclists in Chapter 5.1, the implemented NMT facilities in the case study areas showed significant impact on reducing the levels of EANs of NMT users. Thereby, the NMT facility implementations proved to be successful in improving the levels of safety. However, while there were significant improvements in safety in the case study areas compared to the control areas, the NMT facility implementations still have significant room for improvement as shown in the case study infrastructure assessments.

The NMT facilities that have been implemented in the majority of the case study areas were determined to cater generally well for pedestrians, but the needs of cyclists are often not adequately provided for. This discrepancy between pedestrians and cyclists was also found when looking at the impact that NMT facilities had on the number of NMT trips of the different users. For pedestrians, the investigations indicated that the case study TAZs had noticeably more pedestrian trips than the control TAZs. For cyclists, there was no noticeable impact on the number of cycling trips. The results indicate that the cycling facilities that had been implemented showed limited or no impact in terms of encouraging the number of trips.

By addressing the gaps in the NMT facilities, improving the designs and implementations of NMT facilities (especially for cyclists), NMT trips will become safer, more attractive and more efficient mode of travelling.

### **3. Do these NMT facilities take into consideration the unique challenges of South Africa, namely security concerns, aggressive driving styles and speeding?**

The variation of NMT facility implementations seen in both the case study areas and the control areas means that there is not one defined answer for this question. Some case study implementations, such as Khayelitsha, provide evidence that the local context had been taken into account by completely separating the NMT routes (pedestrian and cyclists) from motorised traffic. However, in other case study areas, such as Sea Point, the lack of clearly allocated cycling routes has resulted in many cyclists still using the motorised road space. As there are many recreational cyclists in this area, the needs of cyclists should have been made more of a priority than what can be seen in the designs. The poor case study infrastructure assessment results of Sea Point align with what was seen in the quantitative investigation of Sea Point. Despite having very recent NMT facility implementations, the EANs for NMT users (particularly cyclists) have actually increased over the recent years.

Additionally, on a national level, there is a downward trend of NMT trips. The only exception were the case study TAZs for pedestrian trips, which had positive increases in the number of trips. This is indicative that on a national level the local challenges have not been appropriately addressed within the design and implementation of the NMT facilities. However, the case study areas of Cape Town demonstrate that if appropriate facilities are installed, as per the requirements of the users, positive change can be made, even within a South African context. Therefore, while security, safety, aggressive driving and other South African elements may be hindering factors, improvements and progress can be made through the implementation of NMT facilities.

There are major improvements that can be made in NMT facility implementations in urban areas of South Africa, so that local challenges and needs of NMT users could be accommodated, more consistently. By adopting the NMT Facility Guidelines (NDoT, 2015), it is more likely that this will be done more successfully.

In conclusion, while there is still significant work to be done, there has been improvement in NMT facility implementation in Cape Town over the years and, therefore, the Proposition 1 holds true. The focus going forward should be to increase the consistency and quality of the NMT facilities that are maintained and improved upon, as well as increasing the reach and connectivity of the NMT network for both pedestrians and cyclists accordingly.

On a national level, this research demonstrates that prioritising the implementation of NMT Facilities as per the recommended guidelines could result in significant and important changes to the transportation systems in the country. Thus, having a direct and powerful impact on South Africa's urban environment (environmental and sustainability benefits), society (socio-economic benefits) and on the individual (safety and health benefits).

PROPOSITION 1, **ACCEPTED VERSION**: “IN CAPE TOWN THERE HAS BEEN AN INCREASE IN THE IMPROVEMENTS OF NMT FACILITIES OVER THE YEARS”

## 7.2 SUMMARY OF PROPOSITION 2

“IN THE AREAS WHERE NMT FACILITIES HAVE IMPROVED, THE SAFETY OF NMT USERS HAS IMPROVED.”

The second proposition explores whether the improvements in the NMT facilities has helped the road safety of NMT users. The following answers are given for the associated research, which is presented in Chapter 5.

### **1. How were the fatalities and injuries trends in the case study areas different from the control areas?**

The fatalities and injuries were investigated in a combined manner by converting the different severity of injuries into EANs. These EAN trends were then investigated to determine the trends of NMT fatalities and injuries over the time period when NMT implementations had occurred. The control areas levels of EANs for NMT users (both pedestrians and cyclists) remained mostly stable, while the case study areas generally had decreasing trends of EANs that resulted in significant reductions in NMT EANs. The declining trends of EANs were more pronounced for pedestrians than they were for cyclists. This indicates that the NMT facilities had a lesser impact for cyclists than the impact that the facilities had for pedestrians.

Another section of the research that aimed to determine how significant the results were the T-tests. The tests looked at whether the changes in the EANs were significant or not. When the T-Tests were performed, the vast majority of the case study areas showed that the decreases in the number of EANs were significant improvements. In the control areas, the T-tests showed that for the vast majority of the controls that no significant decreases in the number of NMT EANs had occurred.

### **2. Which case study and control areas had the highest initial EAN?**

For pedestrians, the case study areas with the highest for 2008 and 2013 were Mitchell’s Plain (1645 EAN) and CBD (734 EAN), respectively. For cyclists, the highest case study area for both 2009 and 2013 was Mitchell’s Plain (60 and 31 EAN respectively).

Out of the control areas, Bishop Lavis had the highest number for pedestrians in 2008 with 640 EAN, while Philippi had the highest number in 2013 with 569 EAN. For cyclists out of the control areas, Kirstenhof had the highest number (69 EAN) in 2009 and Philippi had the highest in 2013 with 33 EAN.

For both the case study areas and the control areas the number of EANs reported for cyclists were significantly smaller than the pedestrians. While some areas have had significant decreasing trends of

EANs, the total number of EANs is still relatively high, for some areas. Mitchell's Plain demonstrated that, while great success has been achieved in the recent years, more needs to be done to reduce the high number of EANs. Therefore, efforts to improve the NMT environment should be ongoing and progressive for the total number of NMT fatalities and injuries to decline, or continue to decline. The control areas demonstrated that the level of EANs are likely to remain constant if facilities are not improved. This was also seen in the overall trends, as discussed in the first question of this section.

### **3. Were there any changes in the safety trends pre-, during- and post-NMT facility improvements?**

The safety trends declined more rapidly during periods of implementations and after implementations than before NMT facility implementations. Some of the case study areas did already have declining rates of EANs before the implementations. It should be noted that even in the control areas there were declining rates, but the declining rates were not sustained (as was found in the case study areas). The control areas showed that it is typical for an area to have alternating periods of declining and increasing EANs, with no long term significant reductions in EANs of NMT users. In the case study areas, the overall declining number of EANs were sustained during and post implementation.

Based on these concluding answers to the research questions, the second proposition is also accepted as true. Furthermore, a revised version of the proposition is now proposed below:

PROPOSITION 2, **EXPANDED VERSION**: "IN THE AREAS WHERE NMT FACILITIES HAVE IMPROVED, THE SAFETY OF NMT USERS HAS IMPROVED BY A SIGNIFICANT AMOUNT FOR PEDESTRIANS BUT NOT NECESSARILY FOR CYCLISTS"

## **7.3 SUMMARY OF PROPOSITION 3**

"NMT IMPROVEMENTS HAVE ALSO HAD A POSITIVE IMPACT ON THE NUMBER OF NMT TRIPS."

The impact that implementing NMT facilities has on the number of NMT trips is another important aspect of moving towards equitable transportation in urban areas of South Africa. Many road users move towards motorised transportation as soon as they can, due to the poor service of NMT trips. Therefore, the proposition of when NMT facilities are improved the number of NMT trips will increase, as these types of trips become more desirable. This notion was investigated using two research questions. The first question regarding general changes in the number of NMT trips in South Africa and the second one investigating the changes of the TAZs of the case study and control areas.

### **1. What changes in the volume of NMT trips in South Africa can be seen between 2003 and 2013?**

Overall, cycling and walking trips declined in volume between 2003 and 2013. In all of the provinces, declines in the number of walking trips to educational institutions were seen. For workers, only two

provinces showed slight increases of walking trips to places of employment. These were KwaZulu-Natal with an increase of 2.4% and Gauteng with 0.2%. The changes seen in Cape Town are discussed in the following question.

**2. In the case study areas that had NMT facility improvements, has there been a significant increase in the number of NMT trips compared to the NMT trips taken in the control areas of Cape Town?**

There was a marked difference between the positive increases seen in the pedestrian trips in the case study TAZs compared with the changes seen in the cycling trips. While the changes in the case study TAZs for pedestrians were noticeably different from the control TAZs and the provincial changes, the cycling changes from 2003 to 2013 in the case study TAZs were not markedly different from the control TAZs or the provincial changes in any way. This indicates that the NMT facilities implemented have been successful for pedestrians but, again, not for the cyclists in the case study areas. Based on the success of the NMT facilities on the number of pedestrian trips, there is potential for NMT facilities to have a positive impact on the number of cycling trips in urban areas of South Africa. However, due to the disintegrated nature of the cycling facilities, inadequate designs, incoherent networks or some other cause, these effects are yet to be seen. From the implementations, the current NMT facilities are more appropriate and effective for pedestrians while the NMT facilities for cycling are lacking to the extent where the implementations are not having the potential impact that they could be. This may be because in the Cape Town, and most likely the South African context as a whole, the needs of pedestrians are better understood than the needs of cyclists.

Therefore, the following changes to the proposition are proposed:

PROPOSITION 3, **EXPANDED VERSION**: “NMT IMPROVEMENTS HAVE ALSO HAD A POSITIVE IMPACT ON THE NUMBER OF PEDESTRIAN TRIPS BUT HAVE HAD A LESSER IMPACT ON CYCLIST TRIPS VOLUMES.”

## 7.4 SUMMARY OF PROPOSITION 4

“THE QUALITY OF THE NMT FACILITIES THAT HAVE BEEN IMPLEMENTED VARIES CONSIDERABLY WITH SOME FACILITIES BEING ADEQUATE, WHILE OTHERS BEING INADEQUATE”

**1. Do the facilities show evidence of the principles as described in the NMT Facility Guidelines (NDoT, 2015) for the type of NMT facility implemented?**

It was found that the principles described in the NMT Facility Guidelines were, generally, not incorporated very well. This indicates that the current practices can be improved upon by incorporating the NMT Facility Guidelines into future designs and implementations. It should be noted that the NMT Facility Guidelines were not available for the NMT implementations and upgrades that were investigated in this research. This probably contributed to the poor evidence of the principles in the NMT facilities.



However, the case study areas proved to have more elements within the NMT facilities that do conform to the principles described. Therefore indicating that practices have been improving in the interim of the NMT Facility Guidelines being published. However, there is still significantly more to be done so that the NMT facility implementations could better embody the principles that are outlined in the NMT Facility Guidelines. In the control areas, the principles were, generally, very poorly applied. Therefore, while the case study areas could be considerably improved upon, the case study areas demonstrate that practitioners in South Africa are improving in terms of designing, implementing and, therefore, addressing the needs of NMT users.

## **2. How do these NMT facility implementation upgrades compare to the facilities in the control areas?**

The overall quality of the NMT facility implementations in the case study areas was, generally, much better than the control areas. As mentioned in the answer to the first question, there are important improvements to the NMT facility implementations that could be made to add value for NMT users.

In the control areas, the designs were clearly outdated and there was very little focus on creating a positive welcoming environment for NMT users. Both the case study areas and the control areas did not show much evidence that any efforts had been made to shorten NMT trip distances. The majority of the NMT facilities were provided directly alongside motorised routes, when in many situations shorter, more efficient paths could have been created. Therefore, in conclusion, the proposition that was drafted at the beginning of the research holds true as it is.

PROPOSITION 4, **ACCEPTED VERSION**: “THE QUALITY OF THE NMT FACILITIES THAT HAVE BEEN IMPLEMENTED VARIES CONSIDERABLY WITH SOME FACILITIES BEING ADEQUATE, WHILE OTHERS BEING INADEQUATE”

Recommendations are now made regarding NMT facility implementations in urban areas of South Africa, and secondly, a few recommendations are made regarding improvements and suggestions for further research within this area of NMT facilities and implementations in urban areas of South Africa.

## **7.6 RECOMMENDATIONS FOR FURTHER RESEARCH IN THIS AREA OF NON-MOTORISED TRANSPORT**

Investigating other urban settlements in South Africa in the manner as described in this research could be the next step in verifying whether the research methods used in this research are transferable to other South African cities. This would help to establish what has happened in regards to NMT as a mode of transport in the various urban areas of South Africa. Further investigations of Johannesburg, Pretoria, Durban and Bloemfontein would help establish a more comprehensive understanding of how NMT facility implementations and upgrades have or have not impacted on safety, the number of NMT trips or the quality of NMT facilities.

As mentioned earlier, future case study infrastructure assessments should be improved upon with generating reviews that are independent of information of the changes in NMT trips and NMT EANS. Additional resources would be needed for this process, as the main researcher would not be able to conduct the assessments, without being influenced by the other investigations. Alternatively the infrastructure assessments could be conducted before the other quantitative investigations.

Furthermore, several research questions could be further investigated. These include the following:

- Which specific NMT links, if upgraded, would greatly improve the connectivity of the existing NMT network, thereby improving the safety of the NMT users along the entire length of their trips, as well as improving the efficiency of NMT trips by establishing seamless and direct routes?
- Investigate the relationship between public transport facilities and NMT facilities.
  - How are public transport and NMT facilities integrated or how are they not integrated?
  - Have would improvements to NMT facilities improve or support public transport services? If not, why?
  - What NMT facilities would make the biggest contribution to improving the level of service experienced by NMT users / public transport users?
- If the rate of NMT facility implementations remains constant, how many more years would it take for Cape Town to have a fully integrated NMT network?
- How long till there is a consistent, adequate level of service for NMT users and when would the number of NMT collision victims be of a more acceptable level when compared to other countries?

From the findings of these research questions, the importance of NMT facilities could be better understood in urban areas of South Africa and, therefore, better prioritised and implemented.

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## APPENDIX A: GROUPING OF NON-MOTORISED TRANSPORT FACILITY PROJECTS

Selection of Non-Motorised Projects (City of Cape Town, 2014)				
No.	Area	Financial year completed	Route Description	Project length
1	Atlantis	2012/13	Reygersdal Road (Witsand to Carel Uys Drive). Reygerdal Road (Charel Uys to Grosvenor Road), Grosvenor Road (Reygersdal Road to Hoop Street and to Charel Uys Drive). Hermes Avenue (Grosvenor Road to Dassenberg Road). Charel Uys Drive (Grosvenor Road to Kerria Road). Grosvenor Road (Fortune Street to Charel Uys and continues along Gardenia Street to Magnolia Street). Meermin Road (Palmer Avenue to Reygerdal Road). Eve Street about 200m, Berzelia Street to, & in front Berzelia Primary School. Kerria Avenue (Gardenia Street to Reygersdal Road continues into Starling Road to Curlew Street). Magnolia Street (Reygersdal Road to Curlew Street). Sampson Street right Curlew Street, left into Fiskaal Street to Starling Road. Meermin Road from Reygersdal Road to Palmer Avenue. Orion Drive from Charel Uys Drive to Montreal Drive (All class 2 shared).	15.2km
2A	Langa	2012/13	Jakkelsvlei Avenue from Vanguard Drive to Kiaat Road. (Class 2 shared) including path linking Als Road to Bonteheuwel Station (class2). Link from Bonteheuwel Station to Jakkelsvlei Road (class1). Also linking Jakkelsvlei Avenue with the day hospital and pedestrian bridge across Vanguard Drive (class 2 shared). Bluegum Avenue Vanguard Drive to Kiaat Road including Saftaan Road linking pedestrian bridge to Heideveld with two desirelines (class 2 shared). Bonteheuwel Avenue from Jakkelsvlei Avenue to Kiaat Road (class 2 shared)	7.0 km
2B		2011/12	Washington Drive between Bhunga Avenue to Vanguard Drive including Jungle Walk to Langa Station (class 2 shared).	3.4 km
2C			Bosduif Road from Heideveld Road to Honeysuckle Road (class 2) Pedestrian walkways on both sides of road and bi-directional cycle way on the eastern side of road.	1.0 km
3A	Gugulethu	2007/08	NY1, from NY3 to NY 6 (Gazela Street) (Class 2 shared)	0.35 km
3B		2009/10	NY 1 Phase 2, from NY 6 (Gazela Street) to Klipfontein Road (NY 108)	1.2 km
3C			Big Lotus: Along the Lotus River from Klipfontein Road to NY3 (class 1)	1.8 km
3D			Phase 3 consists of a Class 3 NMT Facility and runs from Klipfontein Road /NY108 to the N2 overpass	1.0 km
3E			Emms Drive from Japhta Masemola Road to Nyanga Terminus	1.0 km
3F		2012/13	NY1 between NY3 and Japhta Masemola Road including NY75 and NY72 (class 2 shared) project includes a play park as part of the project.	1.94 km
3G			NY3 between Terminus Road and NY3A (class 2 shared)	3.4 km
4A	Steenberg	2013/14	Military Road, from St Christopher Avenue to Henley Road, including Desposition Crescent, Hek Road and St Christopher Avenue. Prince George Drive From Military to Vrygrond Ave, including Vrygrond Avenue.	5.0 km
4B		2012/13	Concert Boulevard from Prince George Drive to Station Road (Retreat) (class 2 shared).	2.6 km
5A	Mitchell's Plain	2012/13	Merrydale Ave between Spine Road and Highlands Drive (class 2 shared)	4.0km
5B			Weltevreden Parkway between Morgenster Road across Highlands Drive to Bond Street (class 2 shared)	2.5 km
6	Dieprivier	2012/13	De Waal Road and Victoria Roads including Dick Burton (NMT movement from Grassy Park to Plumstead employment areas)(class2 shared)	6.1 km

7A	Khayelitsha	2008/09	Spine Road from Govan Mbeki Road to Walter Sisulu Drive (bi-directional Class 2 the southern side)	0.8 km
7B		2009/10	Lwandle Road from Pama Road to Spine Road	1,5 km
7C		2010/11	Spine Road from Walter Sisulu Drive to Mewway (Class 2 both sides)	1,6 km
7D			Walter Sisulu Road from Spine Road to Steve Biko Road (Class 2 both sides)	1,1 km
8A	Sea Point	2009/10	Granger Bay Boulevard from Fritz Sonnenberg to Beach Road (class 2 shared)	0.6 km
8B		2010/11	Somerset Road from Buitengracht Road to Three Anchor Bay Road including the walk to the Green Point Stadium. A bi-directional cycle way and a walkway on the northside of the road.	2.5 km
9A	Cape Town CBD	2010/11	Waterkant Street from Adderley Street to St Joseph's Square, includes the upgrade of St Josephs Square to Chaipinni Street	0.73 km
9B		2011/12	Adderley Street from Strand Street to Company Gardens (bi-directional cycle way). Bree Street from Short Market Street to Hans Strijdom Street (class 3 cycle way both sides). Short Market Street from Bree Street to Adderley Street (Class2 shared), Cape Town CBD, 2011/2012,	1.3 km
10	Milnerton	2011/12	Freedom Way from Koeberg Road to Omarumba Road in Phoenix Village, Democracy Drive from Bosmandam Road to Freedom Way (class 2 shared)	1.7 km

## APPENDIX B: PEDESTRIAN EQUIVALENT ACCIDENT NUMBER GRAPHS

The graphs presented here are the pedestrian EAN trends for both the case study areas as well as the control areas. Two summary graphs are presented first, after which the case study graphs are presented in the same order as the grouping of the projects.

### B.1 CASE STUDY AREAS

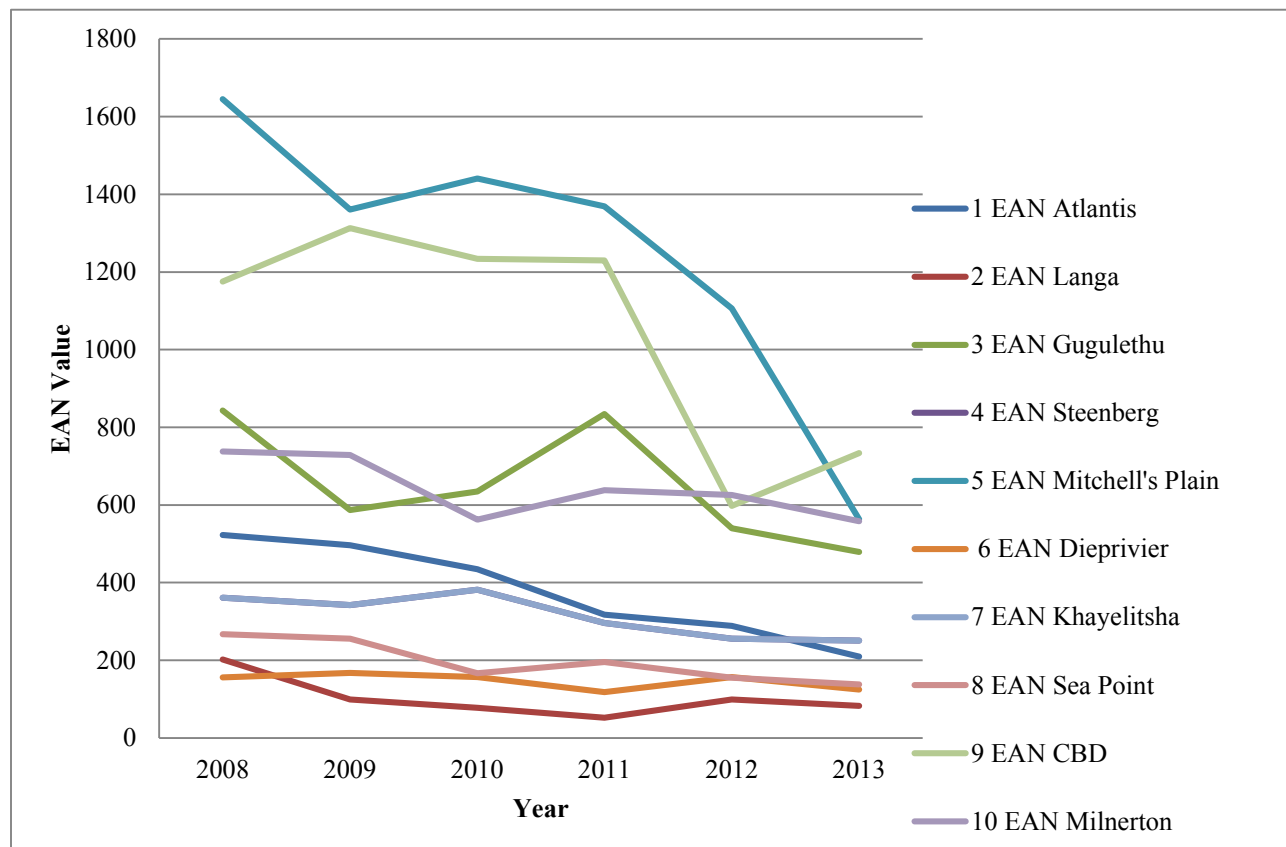


Figure 55: Equivalent Accident Numbers of Pedestrian Case Study Areas



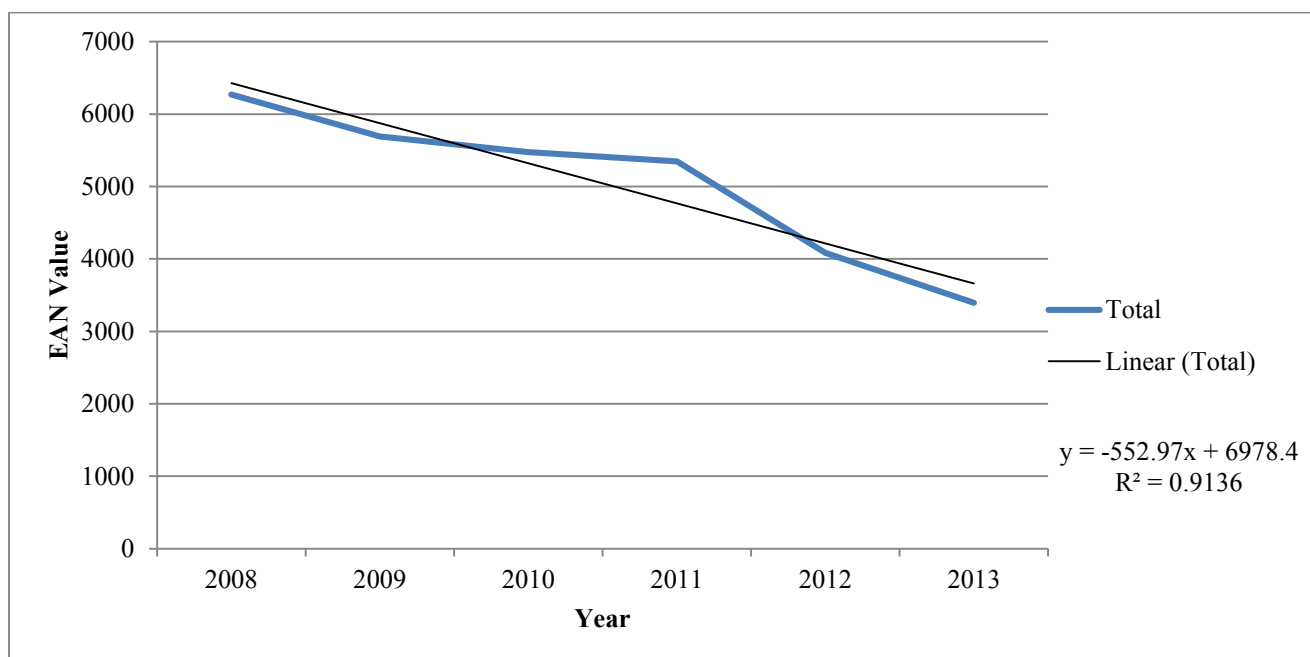


Figure 56: Total of all Pedestrian Equivalent Accident Number of Case Study Areas

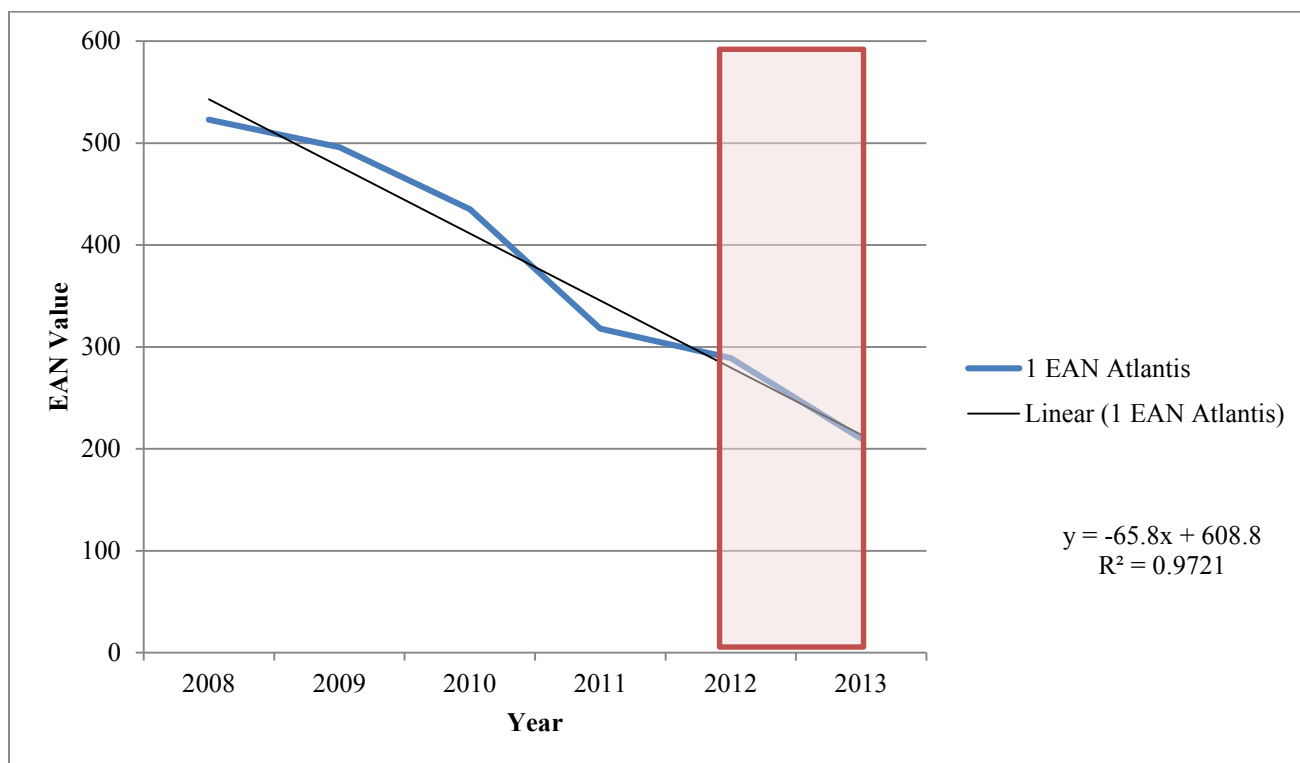


Figure 57: Pedestrian Equivalent Accident Number of Atlantis with Block indicating Facility Upgrades

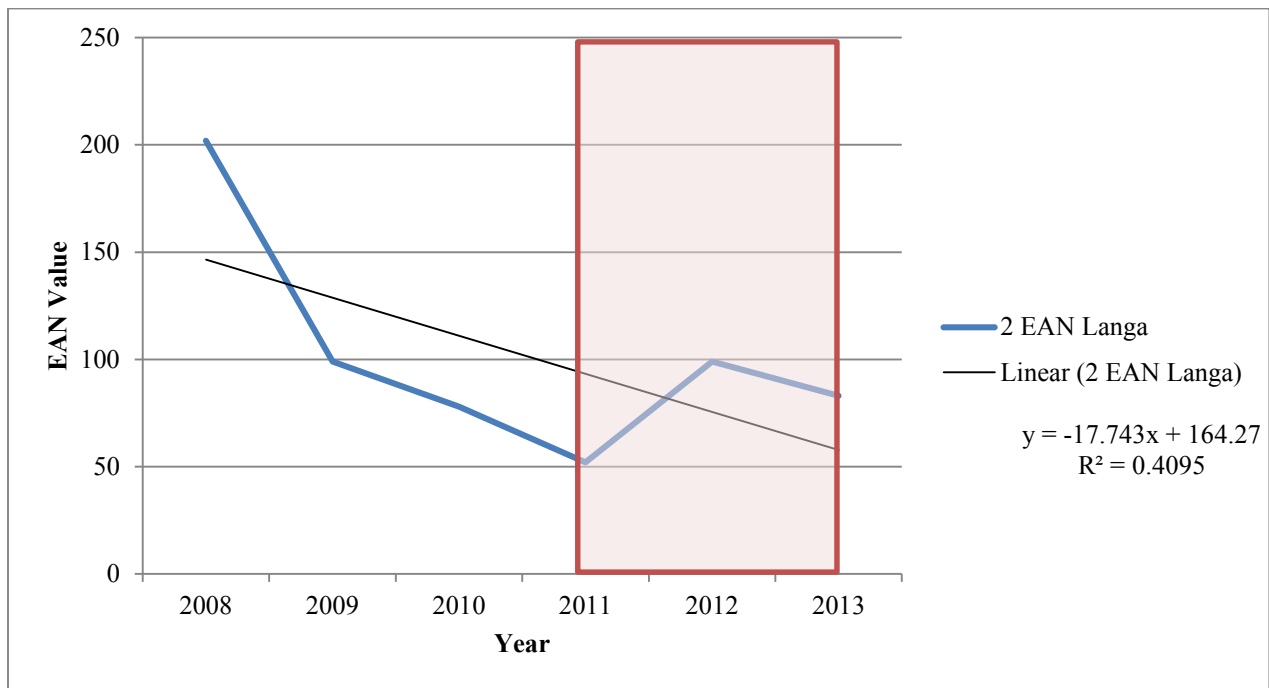


Figure 58: Pedestrian Equivalent Accident Number of Langa with Block indicating Facility Upgrades

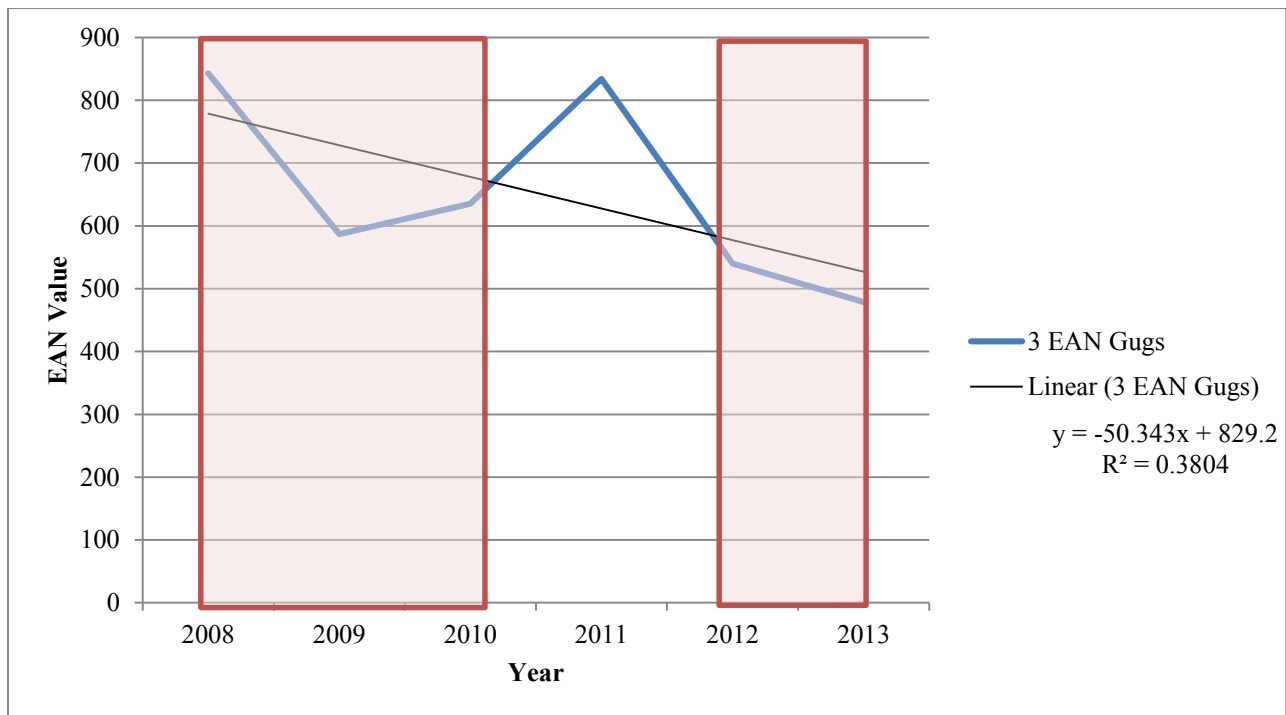


Figure 59: Pedestrian Equivalent Accident Number of Gugulethu with Blocks indicating Facility Upgrades

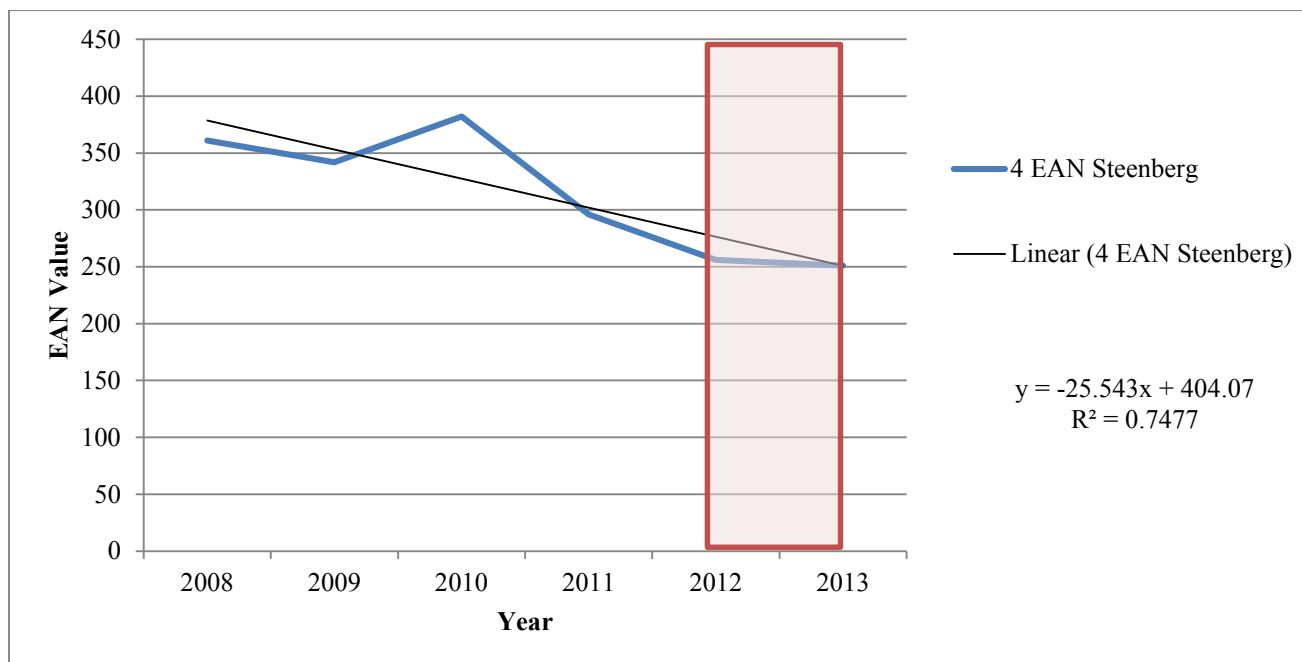


Figure 60: Pedestrian Equivalent Accident Number of Steenberg with Block indicating Facility Upgrades

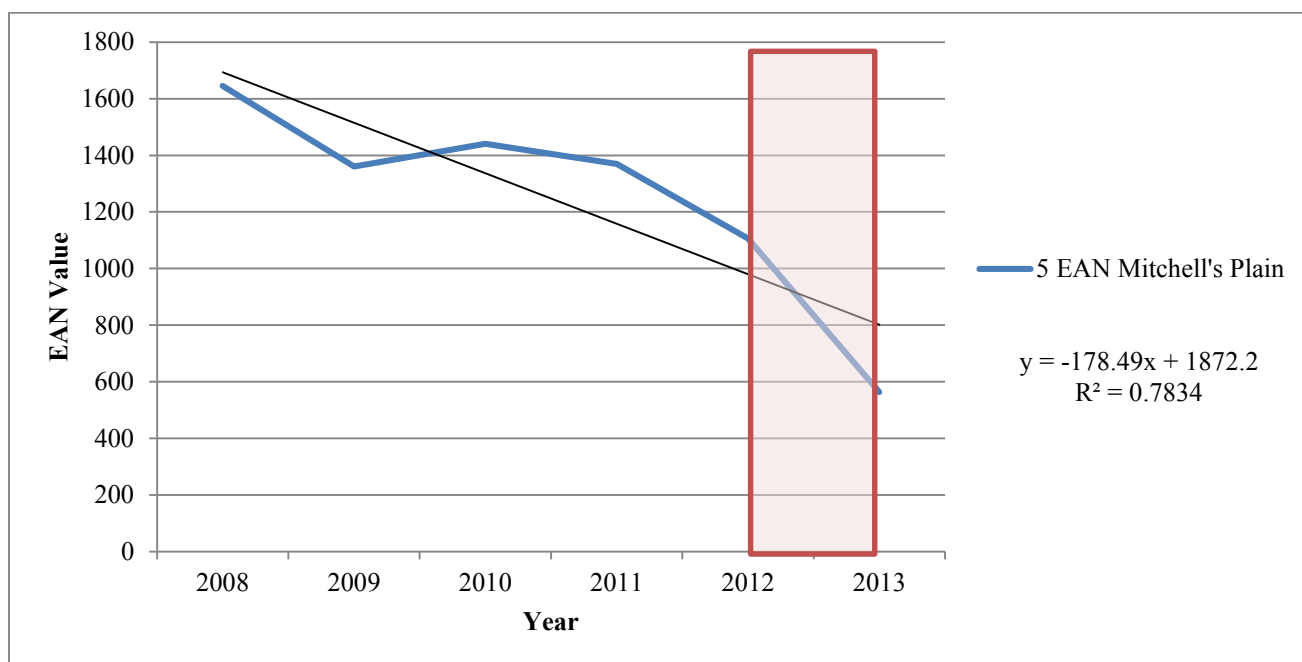


Figure 61: Pedestrian Equivalent Accident Number of Mitchell's Plain with Block indicating Facility Upgrades

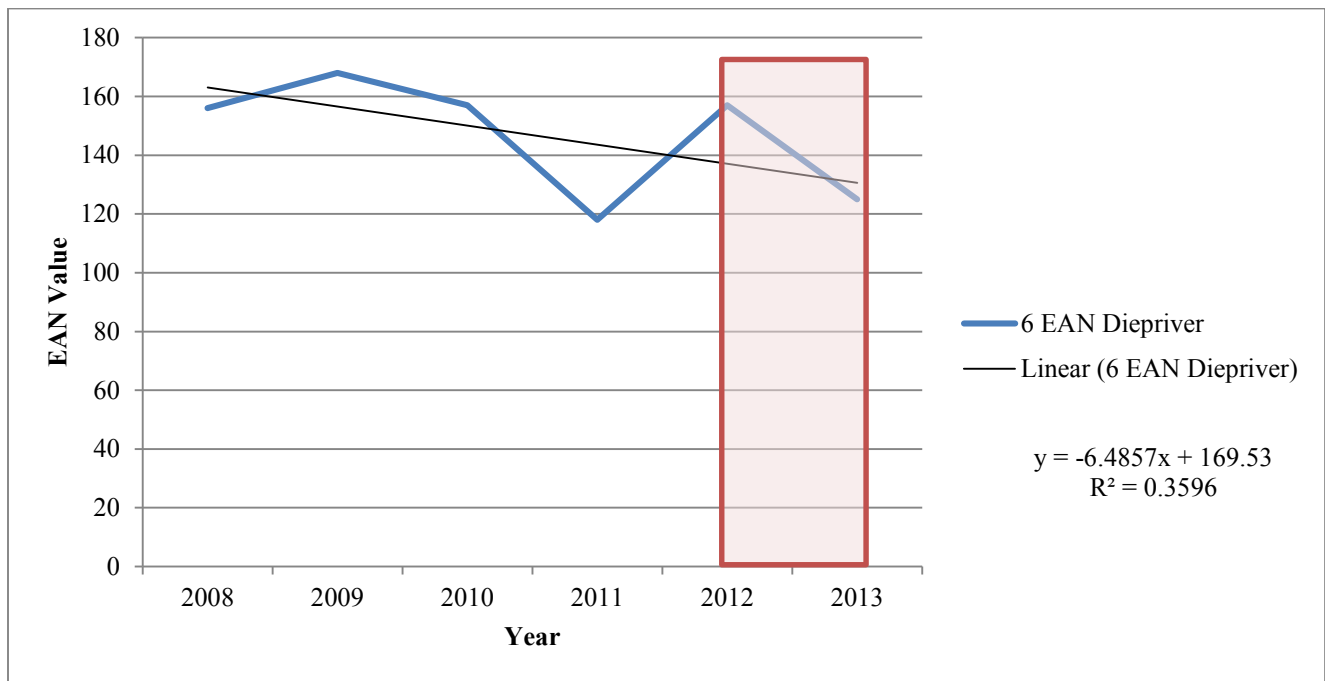


Figure 62: Pedestrian Equivalent Accident Number of Diepriver with Block indicating Facility Upgrades

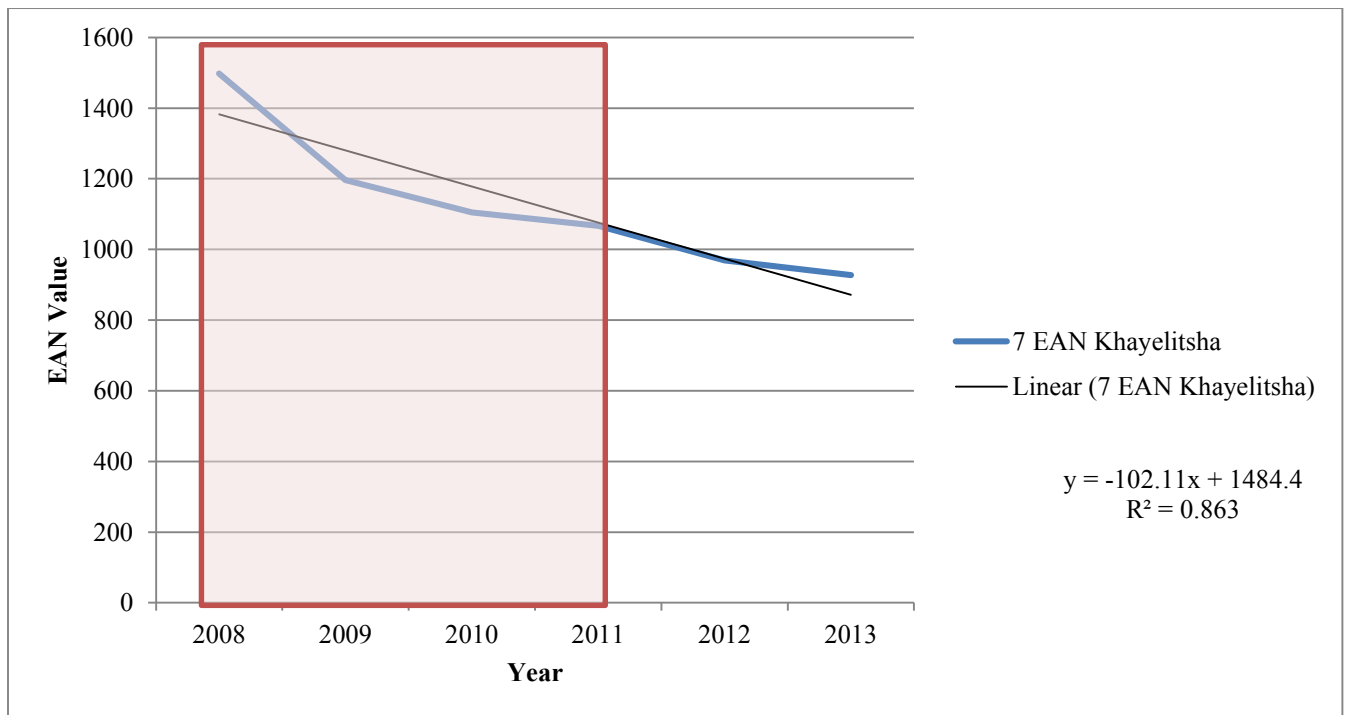


Figure 63: Pedestrian Equivalent Accident Number of Khayelitsha with Block indicating Facility Upgrades

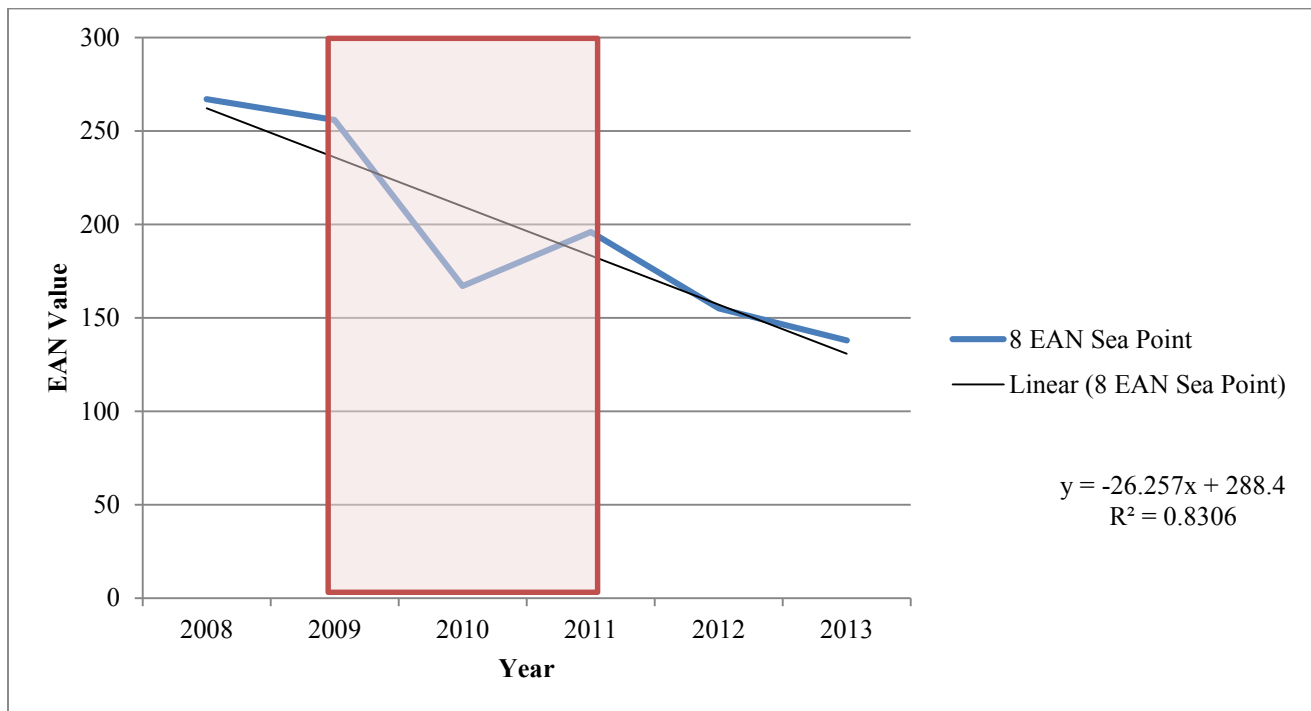


Figure 64: Pedestrian Equivalent Accident Number of Sea Point with Block indicating Facility Upgrades

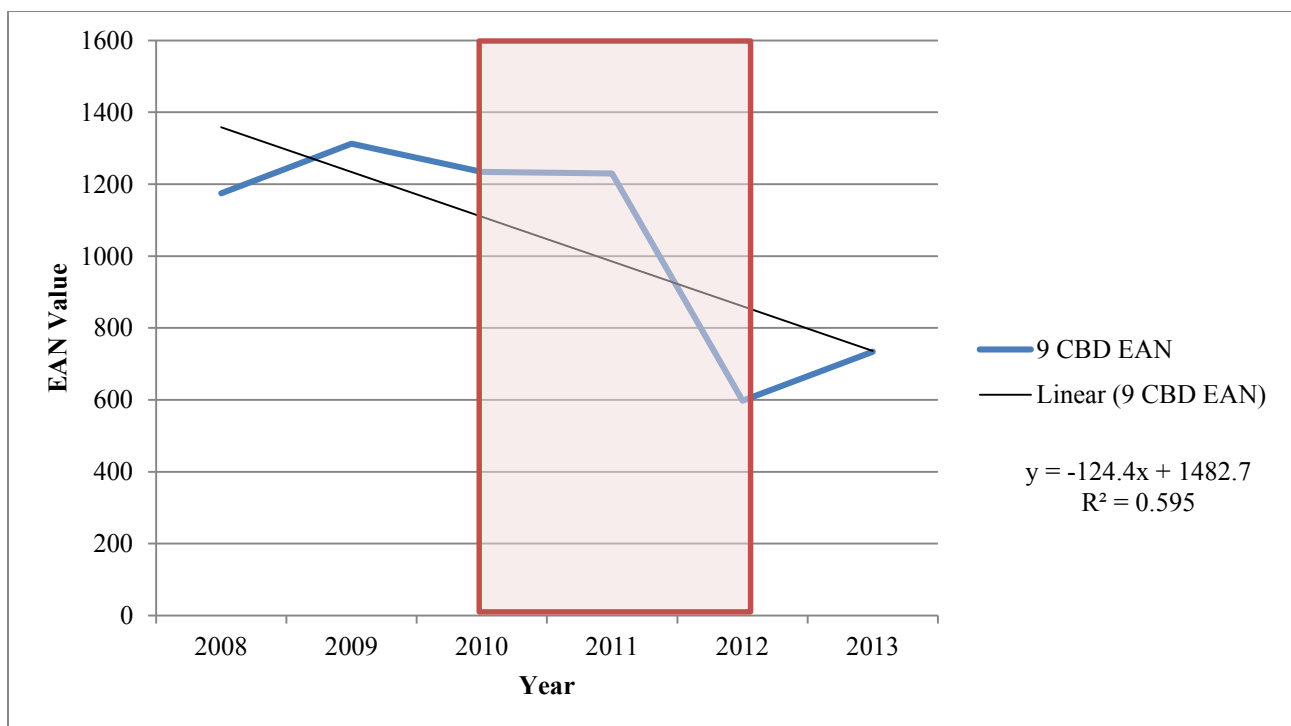


Figure 65: Pedestrian Equivalent Accident Number of Cape Town's CBD with Block indicating Facility Upgrades

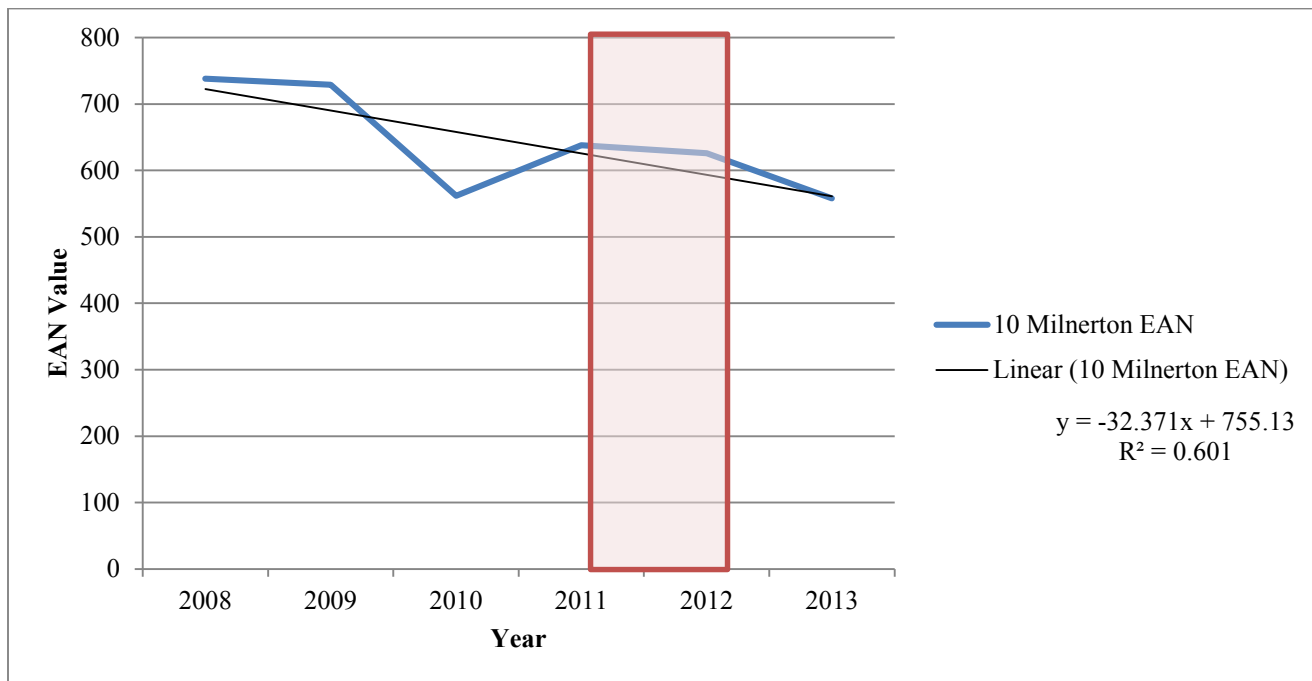


Figure 66: Pedestrian Equivalent Accident Number of Milnerton with Block indicating Facility Upgrades

## B.2 CONTROL STUDY AREAS

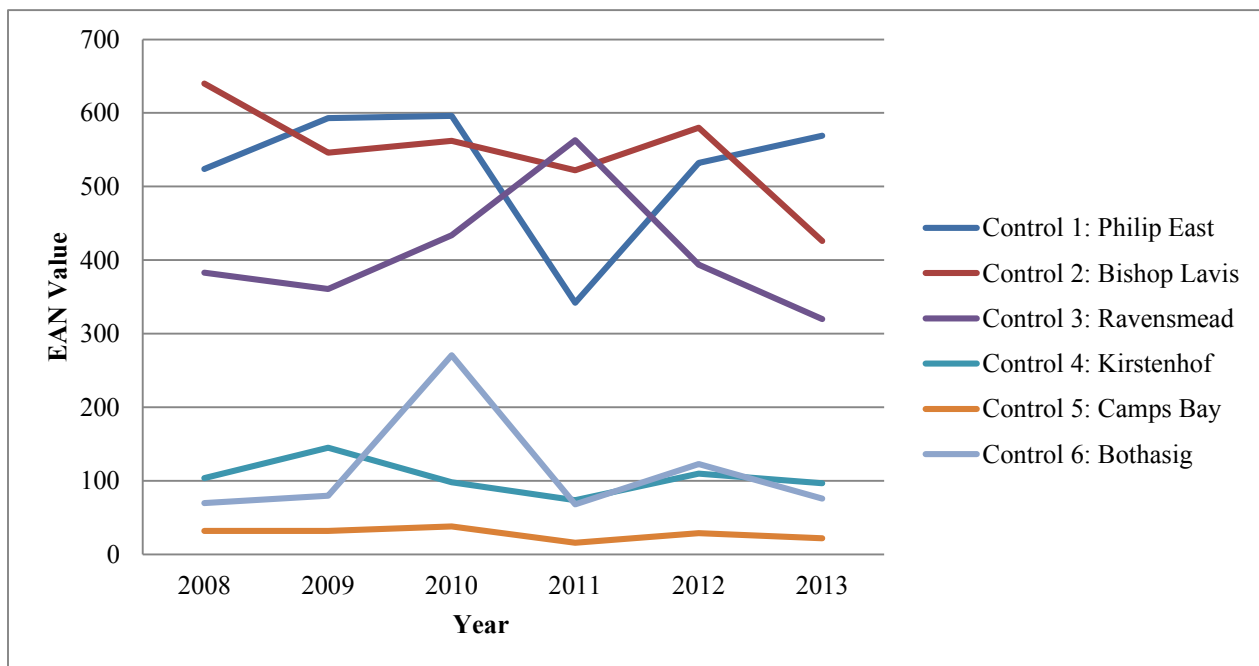


Figure 67: Pedestrian Equivalent Accident Number of Control Areas



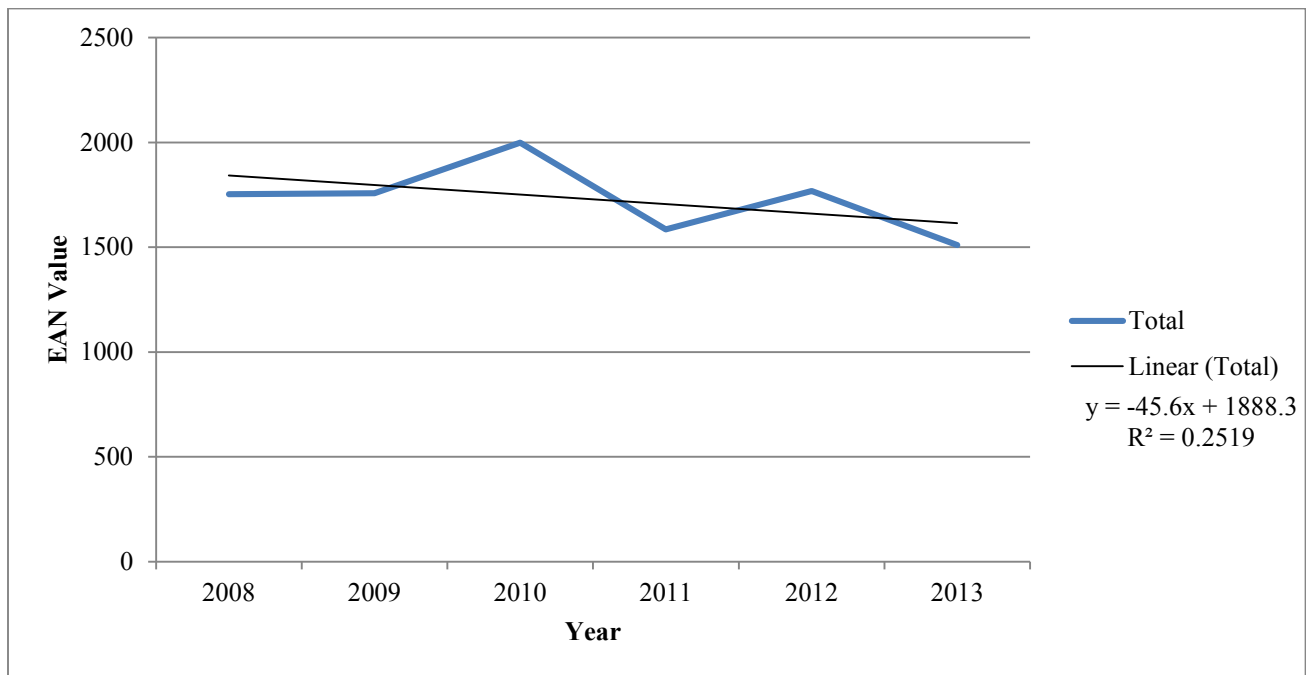


Figure 68: Total Pedestrian Equivalent Accident Number of Control Areas

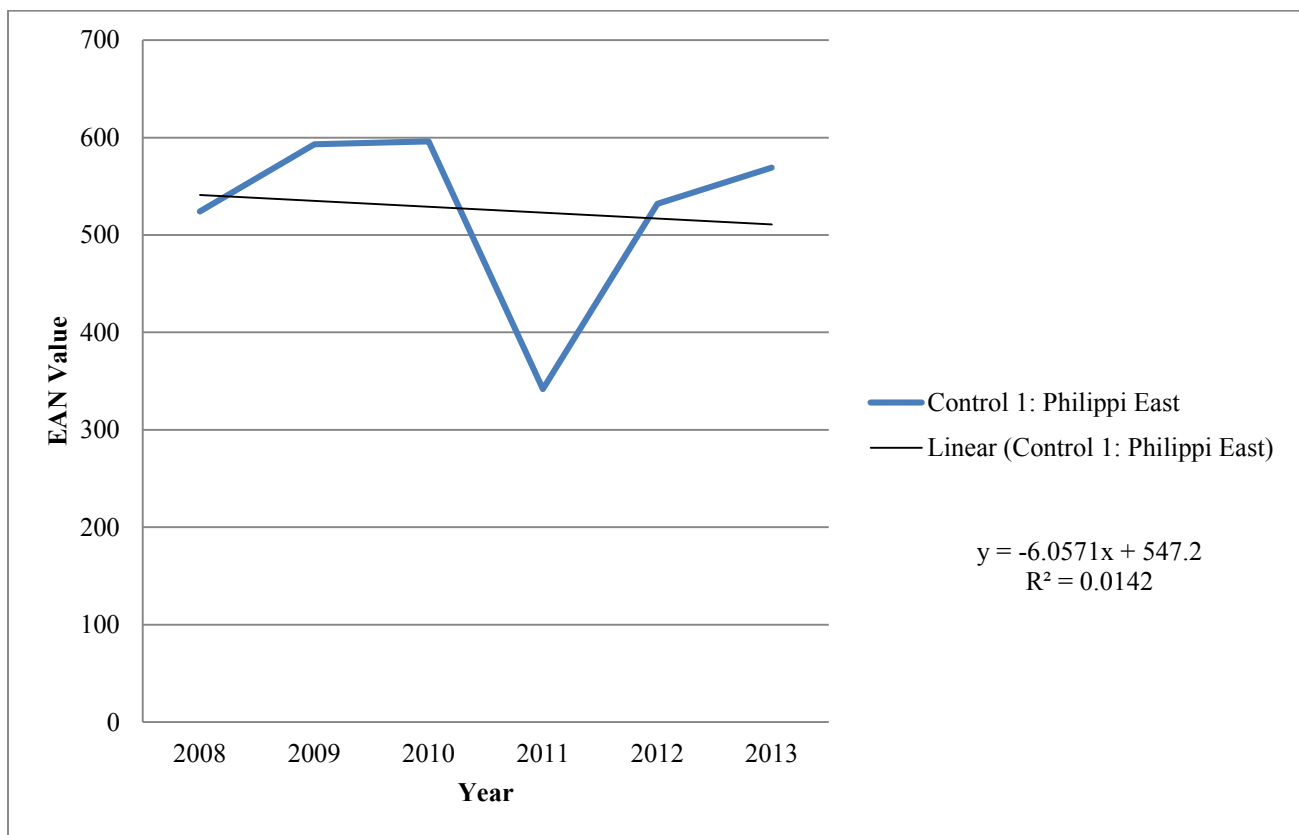


Figure 69: Pedestrian Equivalent Accident Number of Philippi

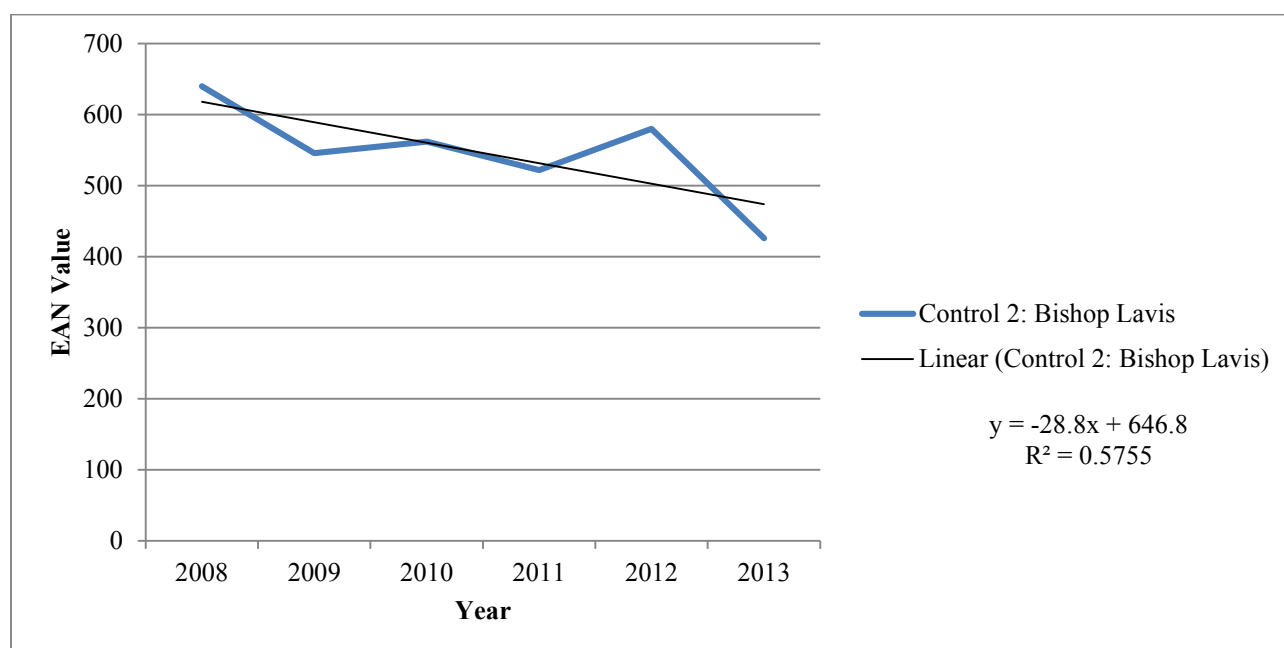


Figure 70: Pedestrian Equivalent Accident Number of Bishop Lavis

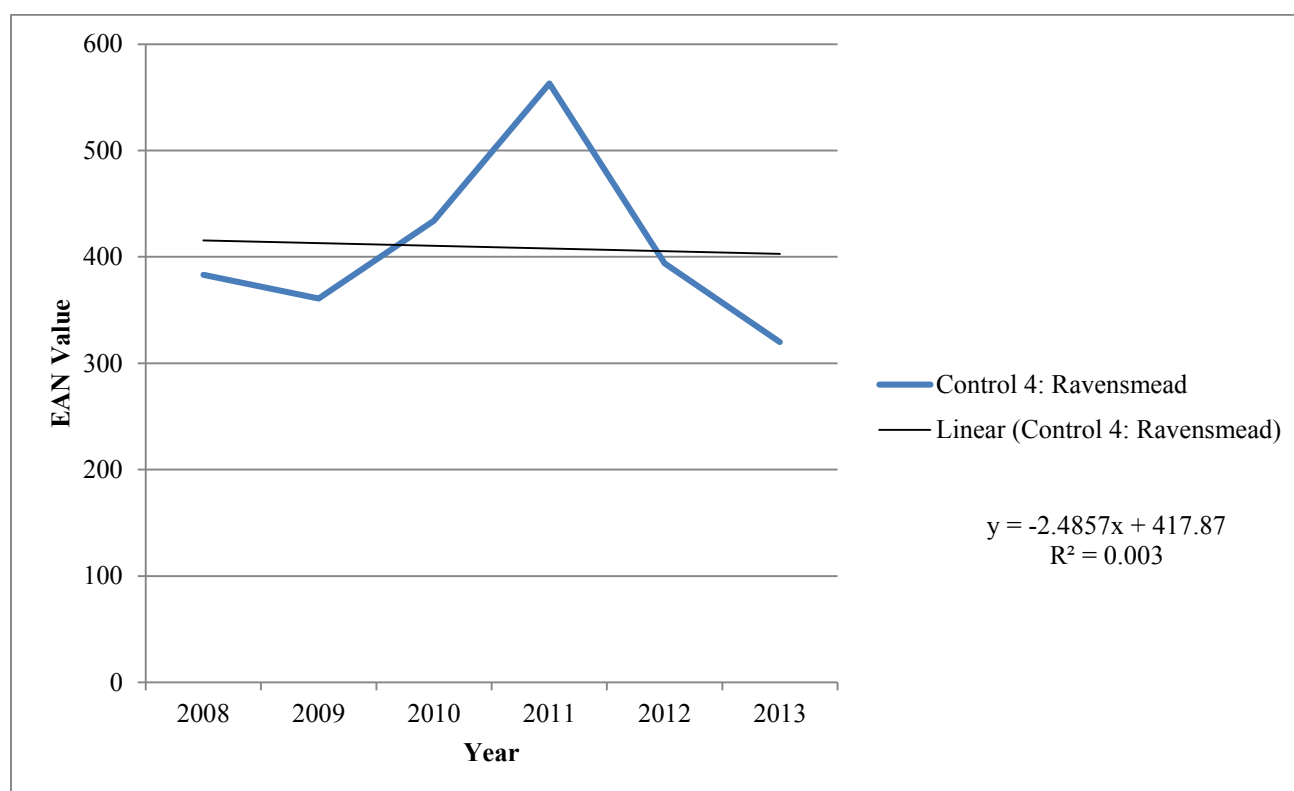


Figure 71: Pedestrian Equivalent Accident Number of Ravensmead

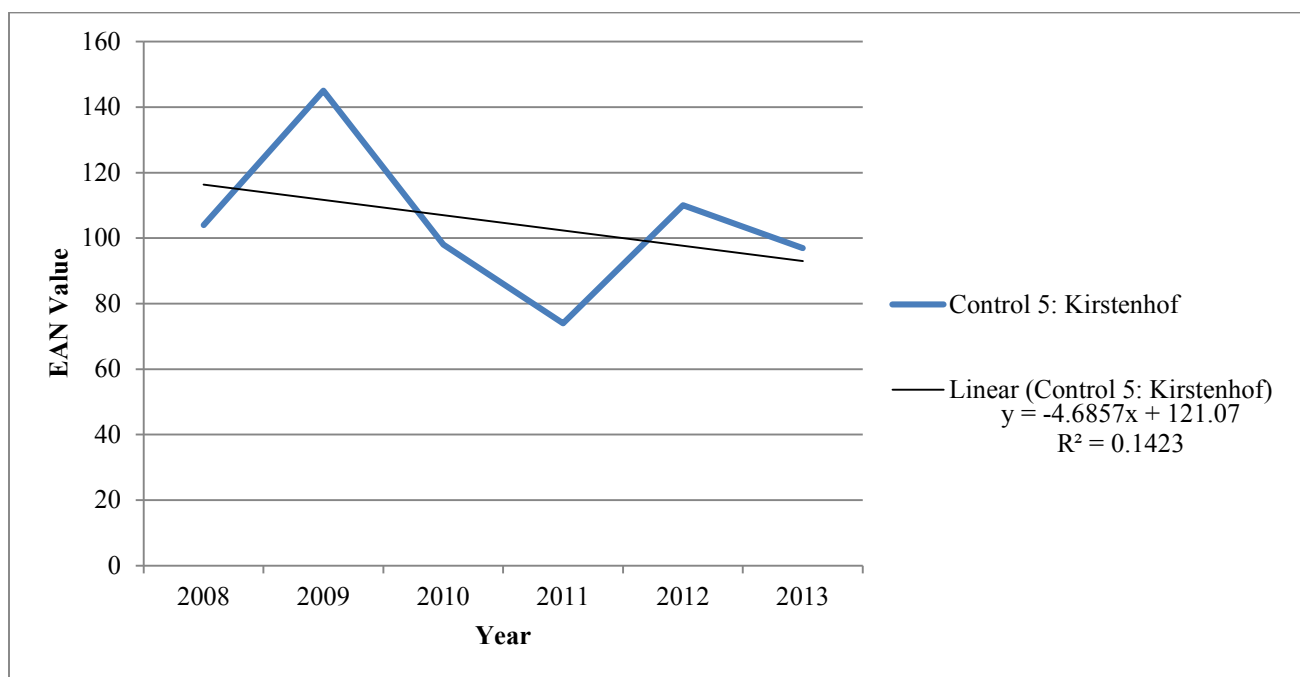


Figure 72: Pedestrian Equivalent Accident Number of Kirstenhof

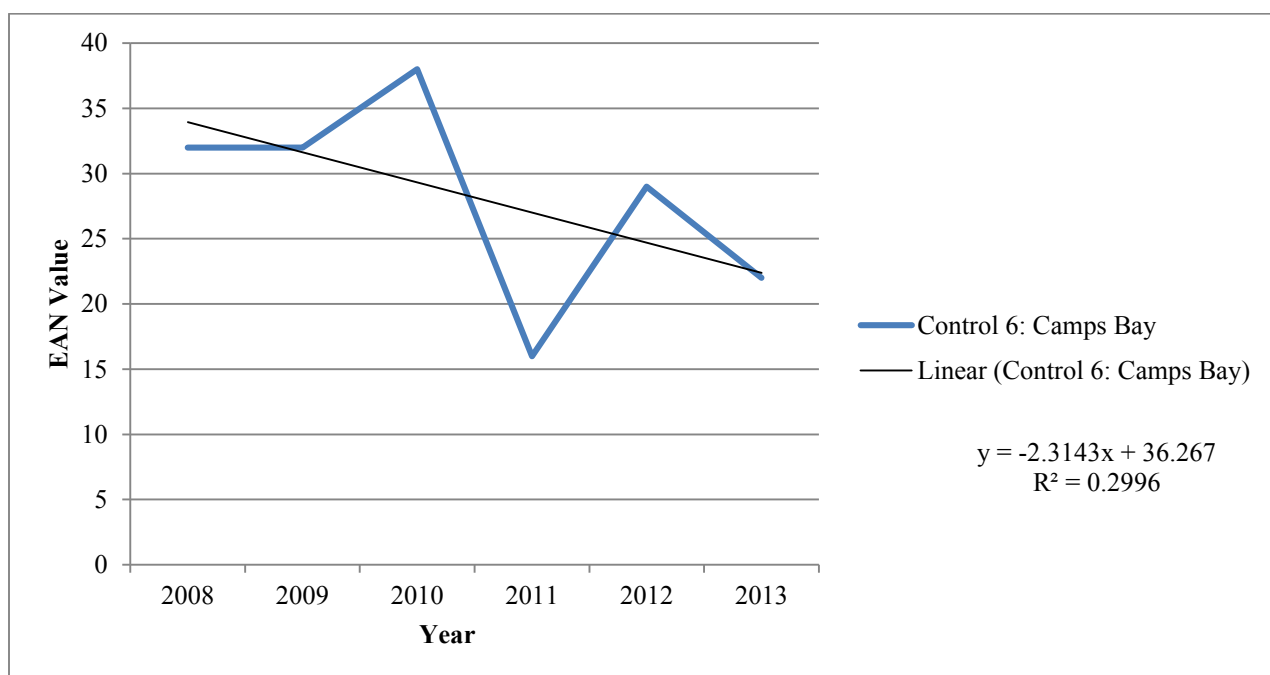


Figure 73: Pedestrian Equivalent Accident Number of Camps Bay

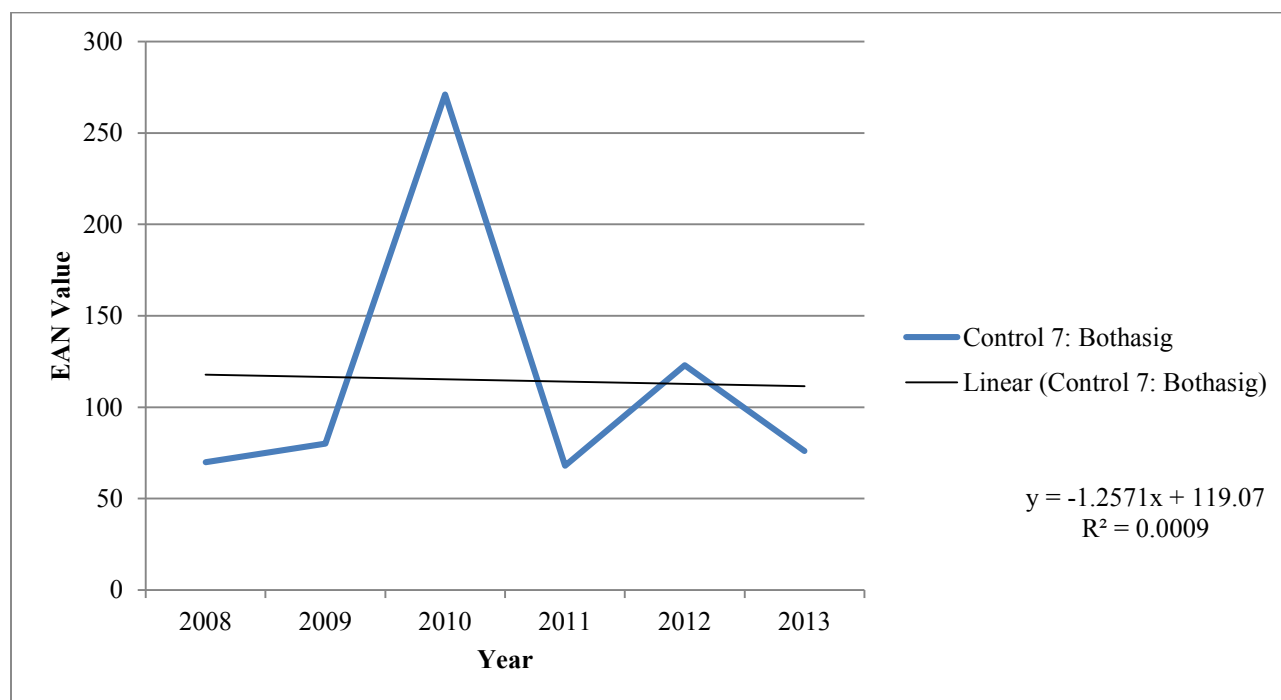


Figure 74: Pedestrian Equivalent Accident Number of Bothasig

## APPENDIX C: CYCLIST EQUIVALENT ACCIDENT NUMBER

The graphs presented here are the cyclist EAN trends for both the case study areas as well as the control areas. Two summary graphs are presented first after which the case study graphs are presented in the same order as the grouping of the projects.

### C.1 CASE STUDY AREAS

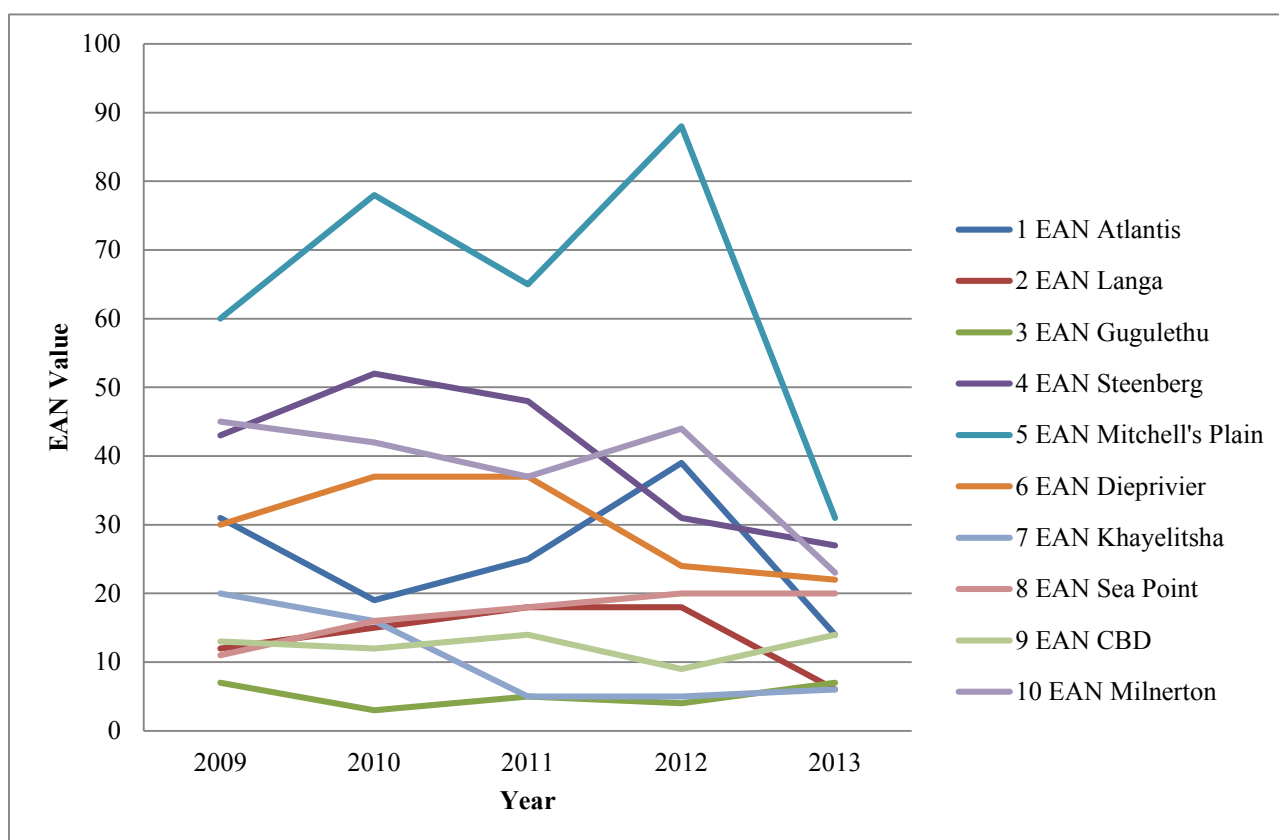


Figure 75: Equivalent Accident Number of Cyclists for Case Study Areas

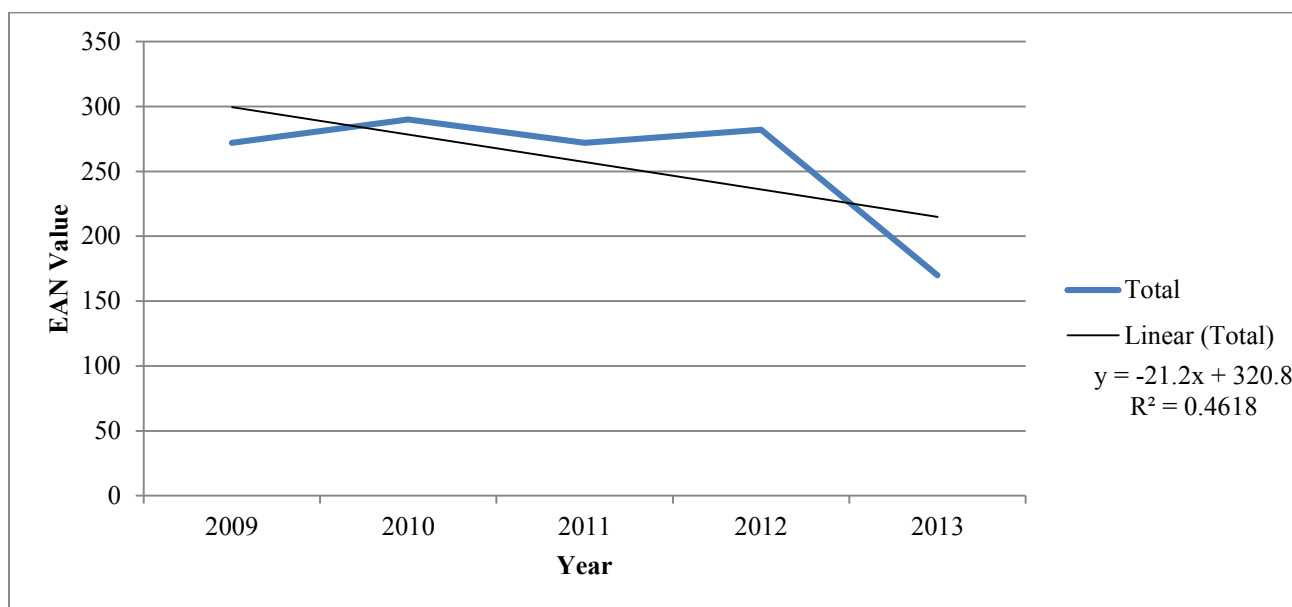


Figure 76: Total Equivalent Accident Number of Cyclists for Case Study Areas

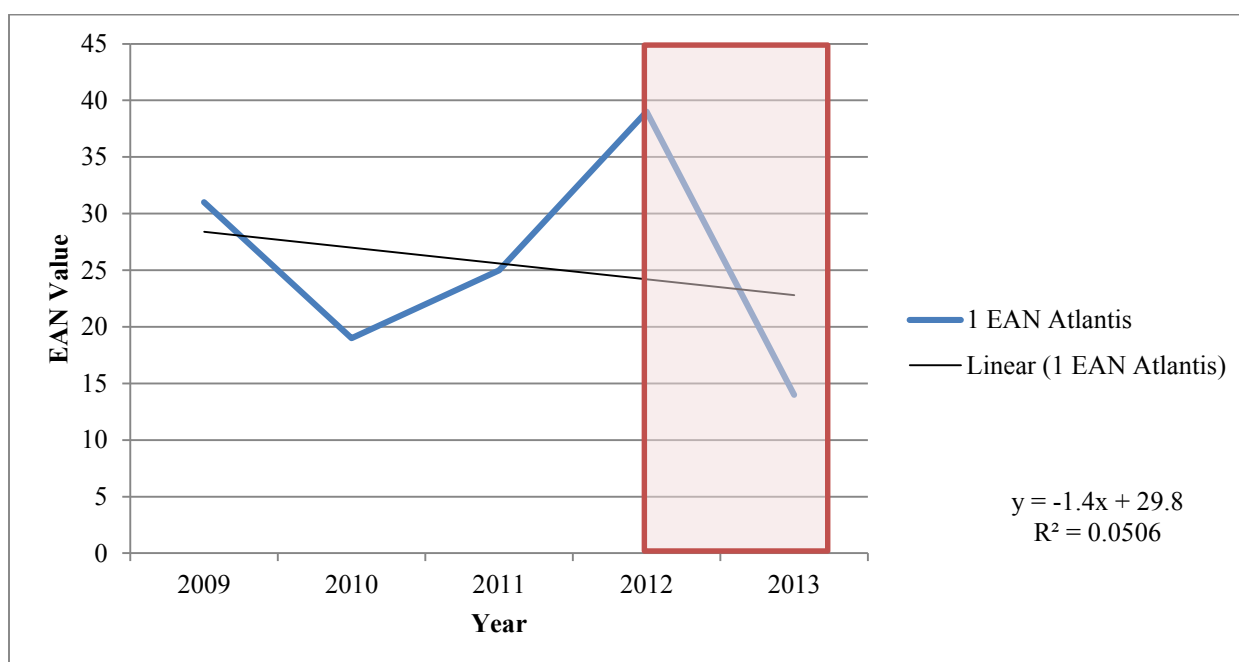


Figure 77: Cyclist Equivalent Accident Number of Atlantis with Block Indicating Facility Upgrades



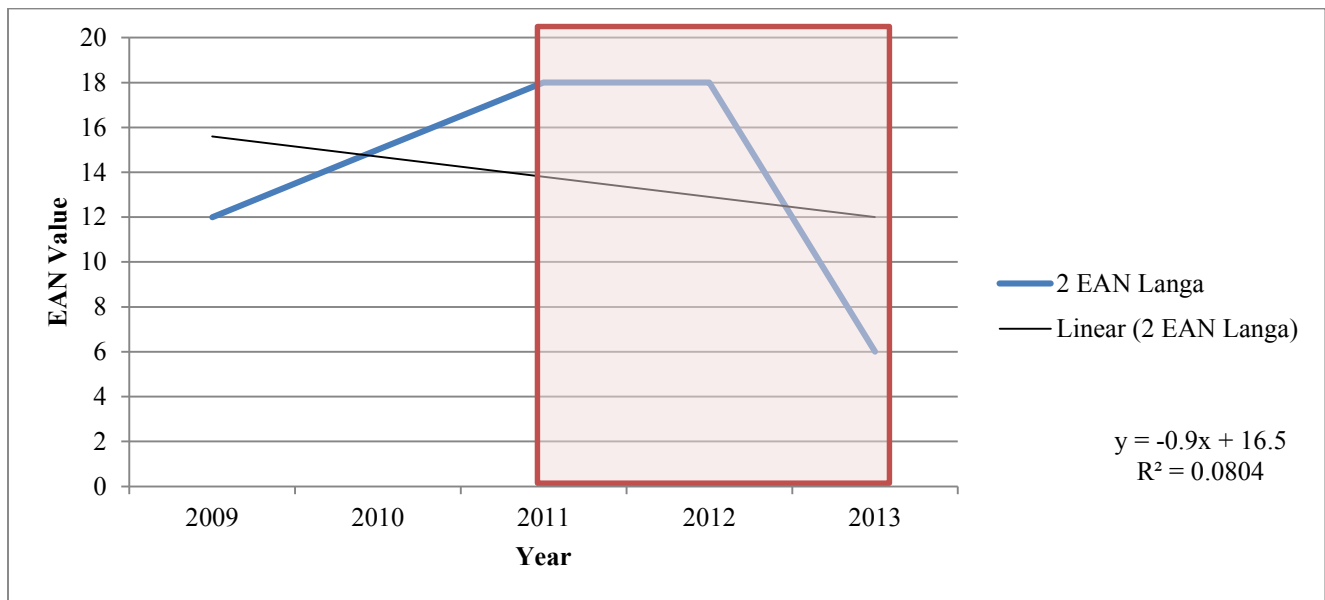


Figure 78: Cyclist Equivalent Accident Number of Langa with Block indicating Facility Upgrades

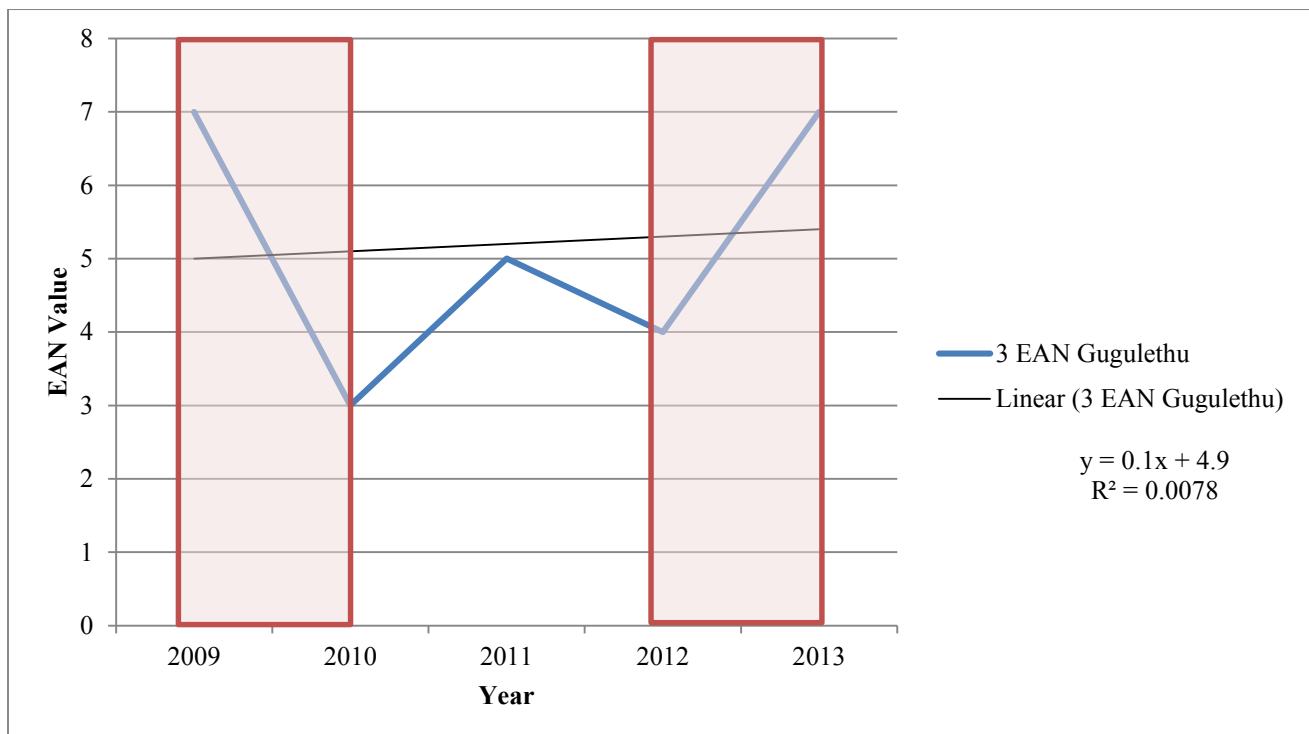


Figure 79: Cyclist Equivalent Accident Number of Gugulethu with Blocks indicating Facility Upgrades

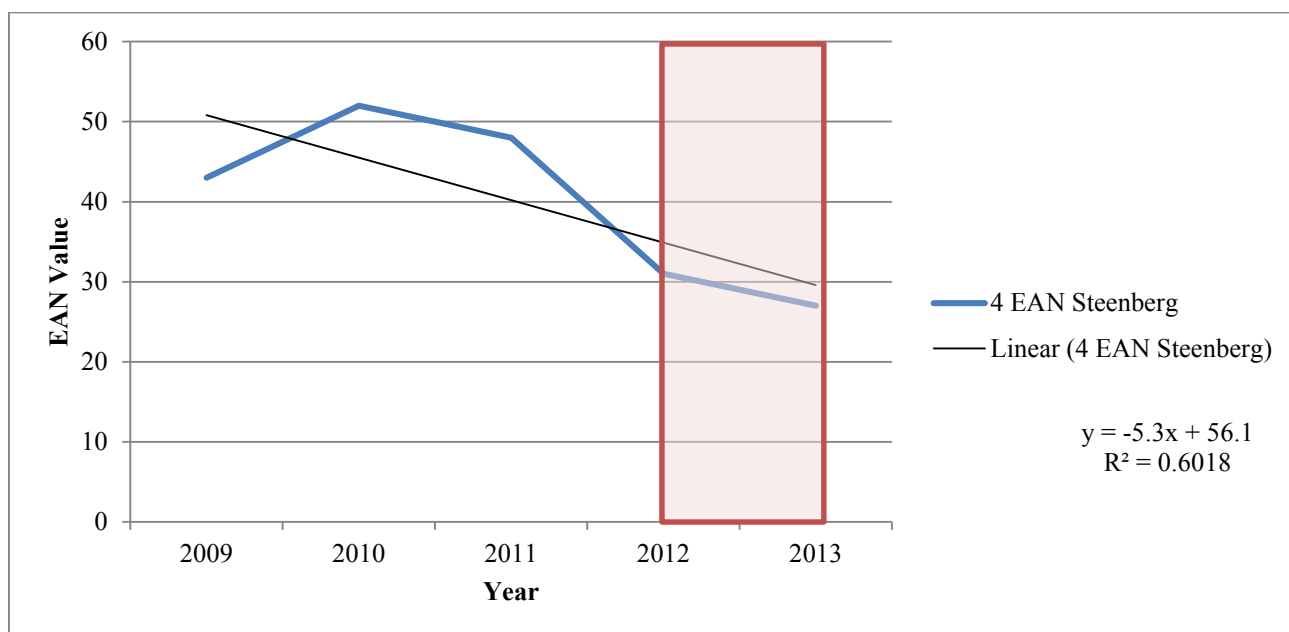


Figure 80: Cyclist Equivalent Accident Number of Steenberg with Block indicating Facility Upgrades

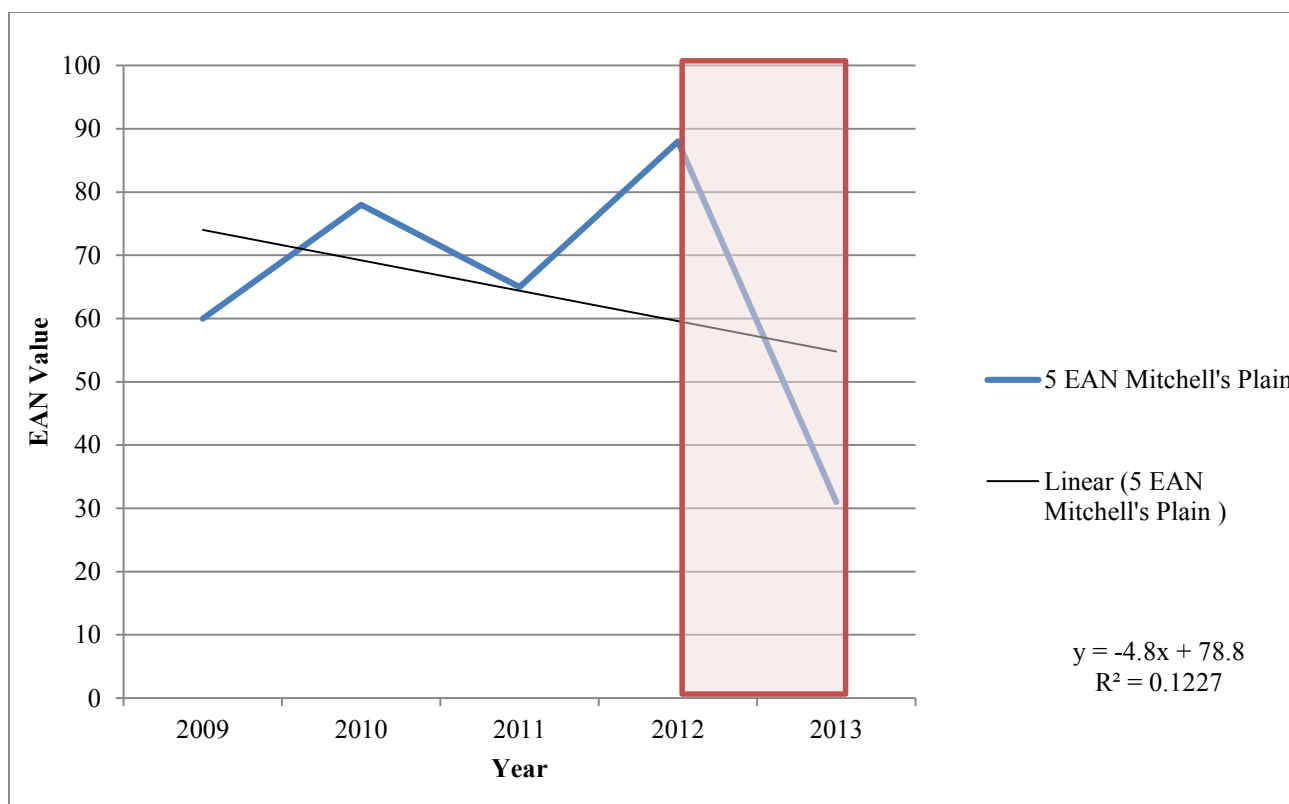


Figure 81: Cyclist Equivalent Accident Number of Mitchells Plain with block indicating Facility Upgrades

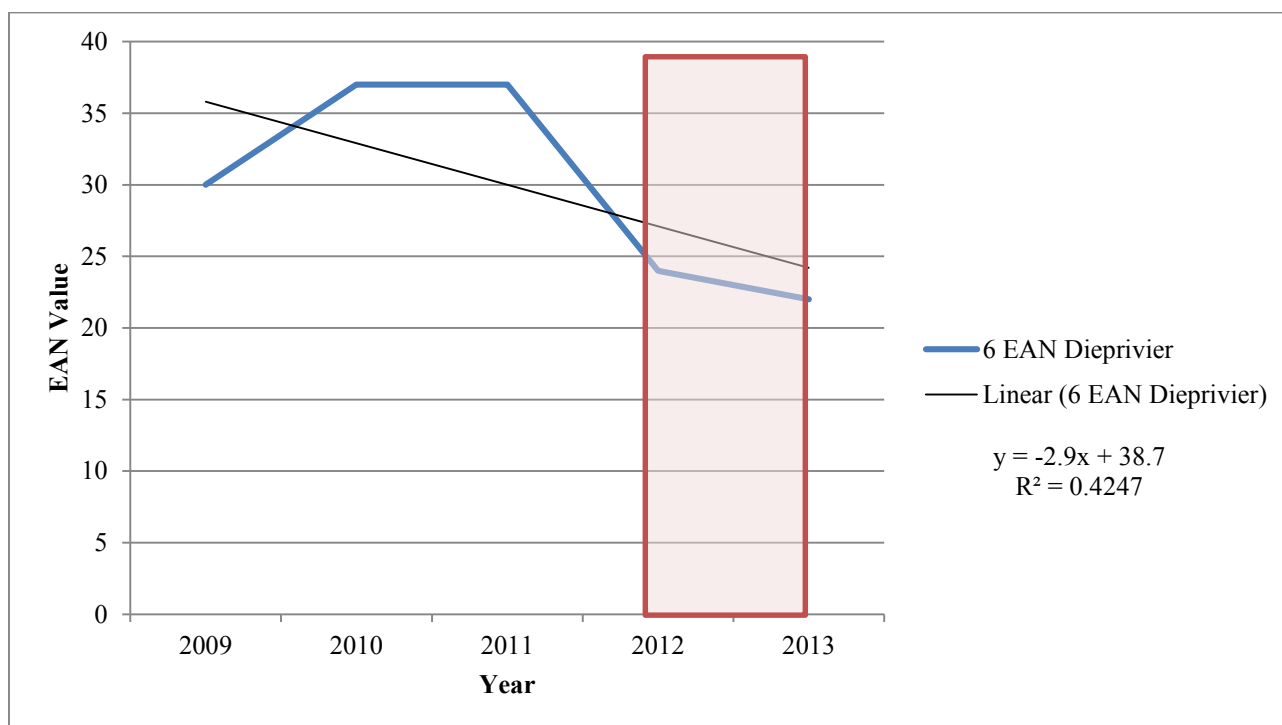


Figure 82: Cyclist Equivalent Accident Number of Dieprivier with Block indicating Facility Upgrades

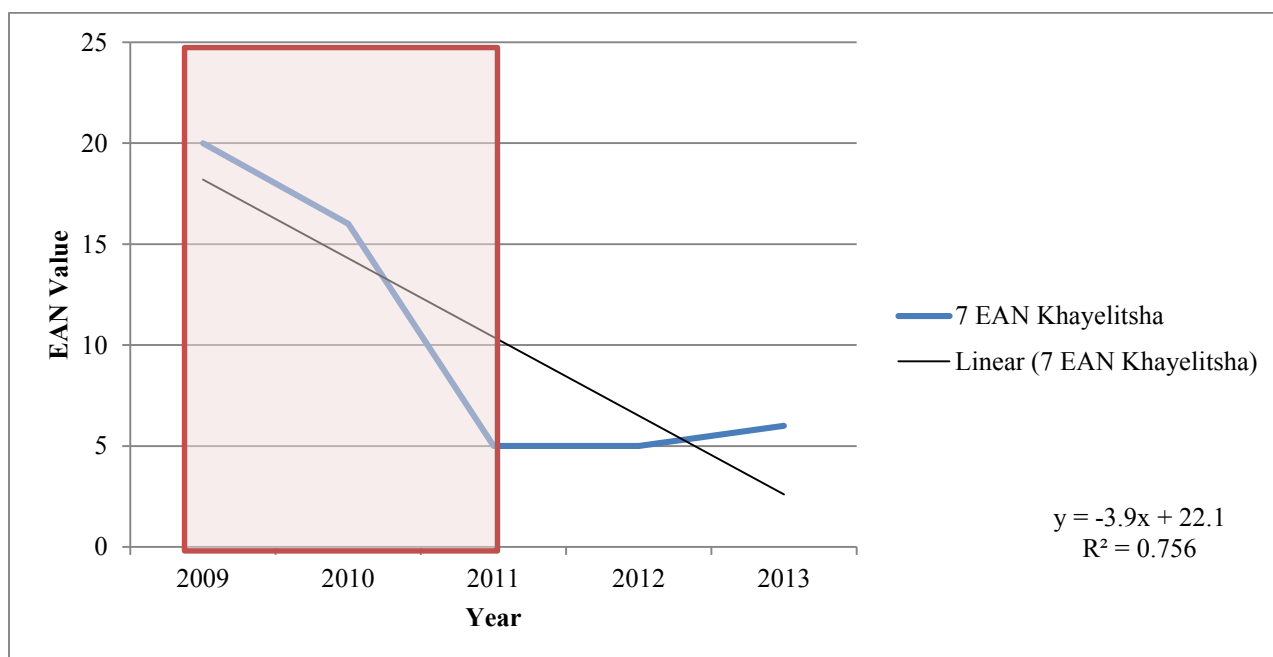


Figure 83: Cyclist Equivalent Accident Number of Khayelitsha with Block indicating Facility Upgrades

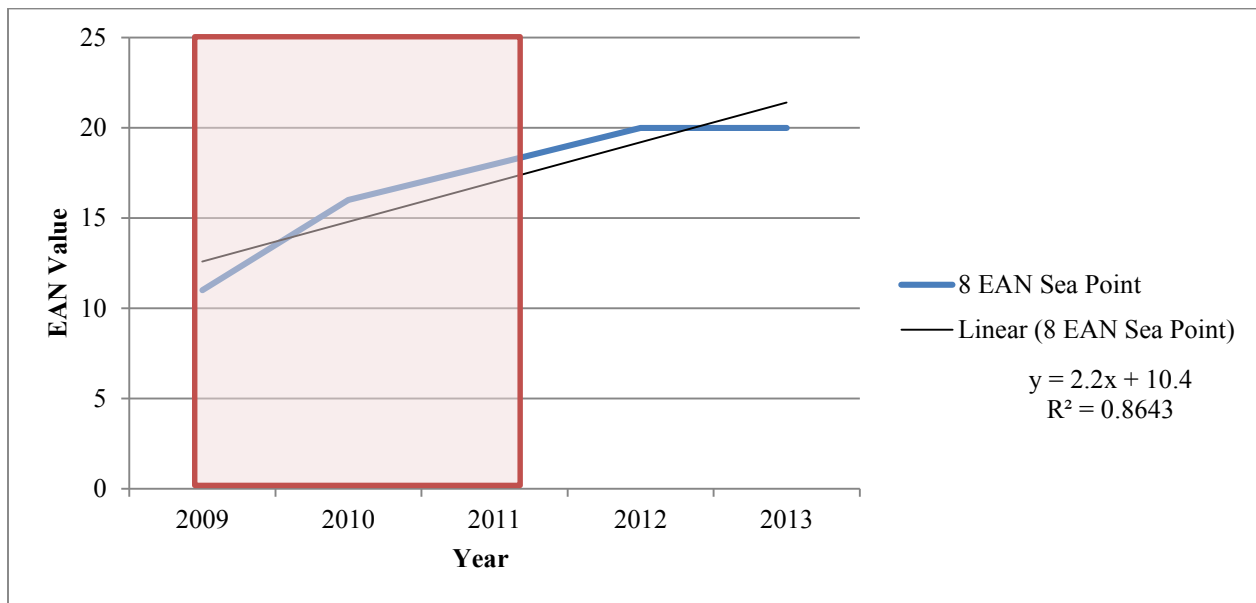


Figure 84: Cyclist Equivalent Accident Number of Sea Point with Block indicating Facility Upgrades

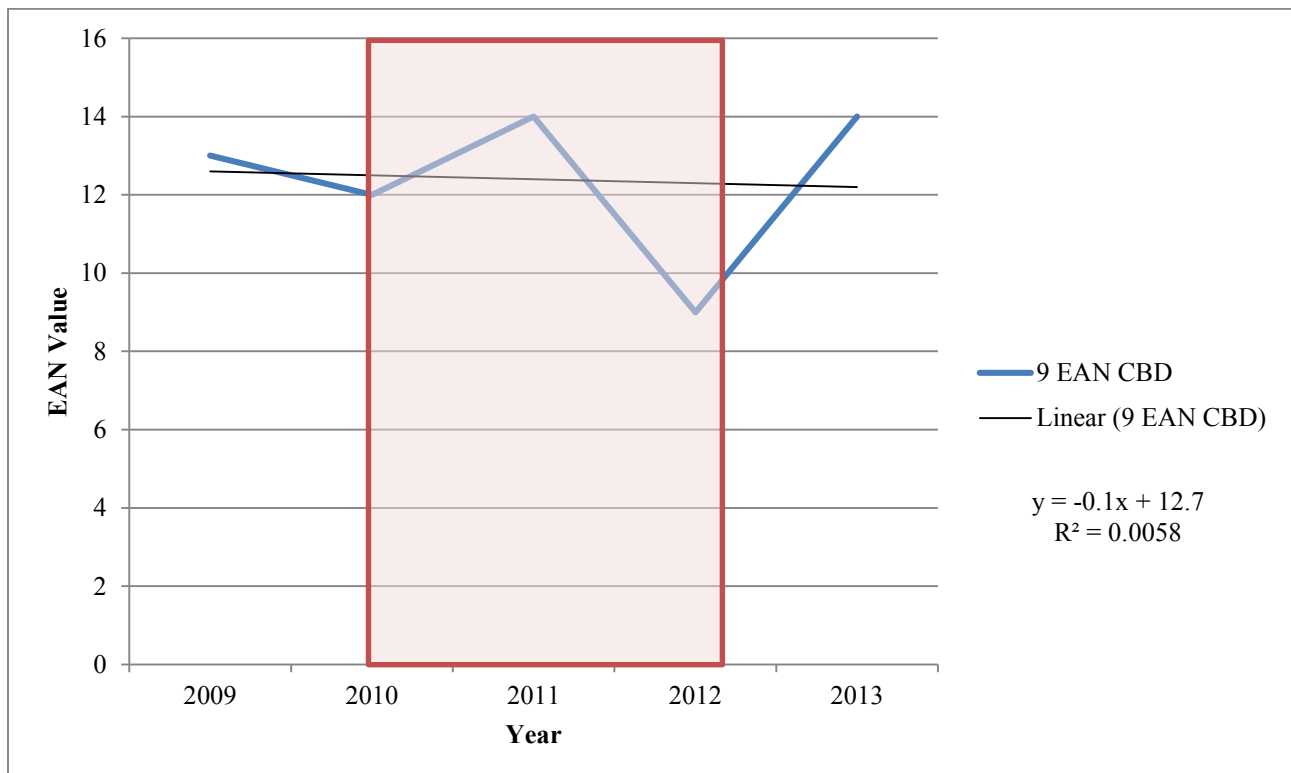


Figure 85: Cyclist Equivalent Accident Number of CBD with Block indicating Facility Upgrades

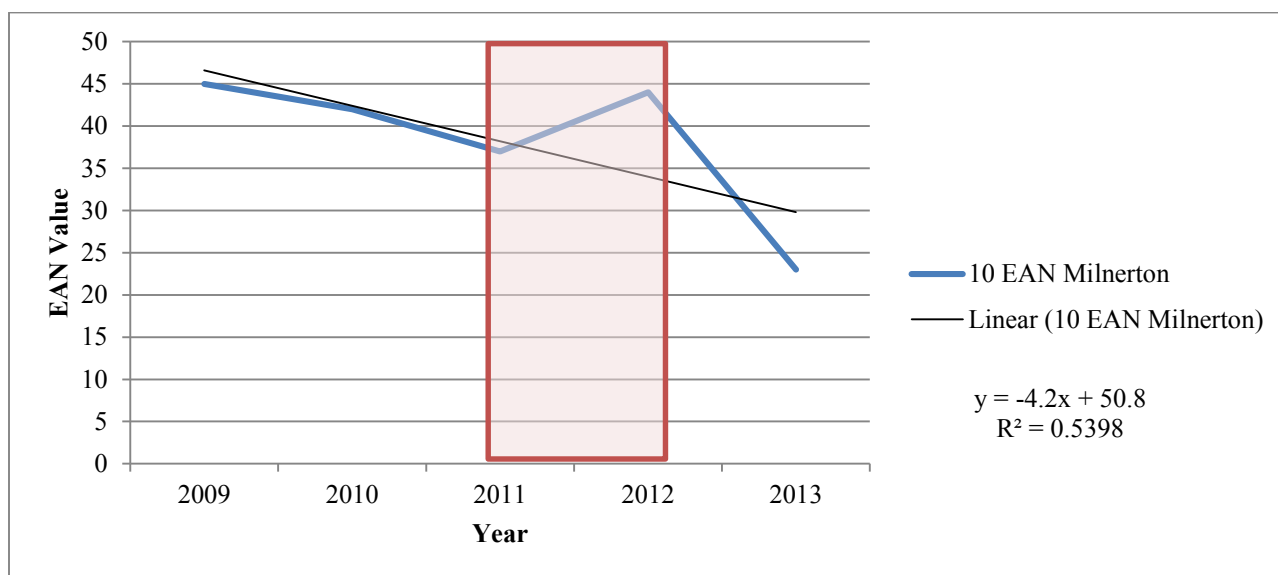


Figure 86: Cyclist Equivalent Accident Number of Milnerton with Block indicating Facility Upgrades

## C.2 CONTROL STUDY AREAS

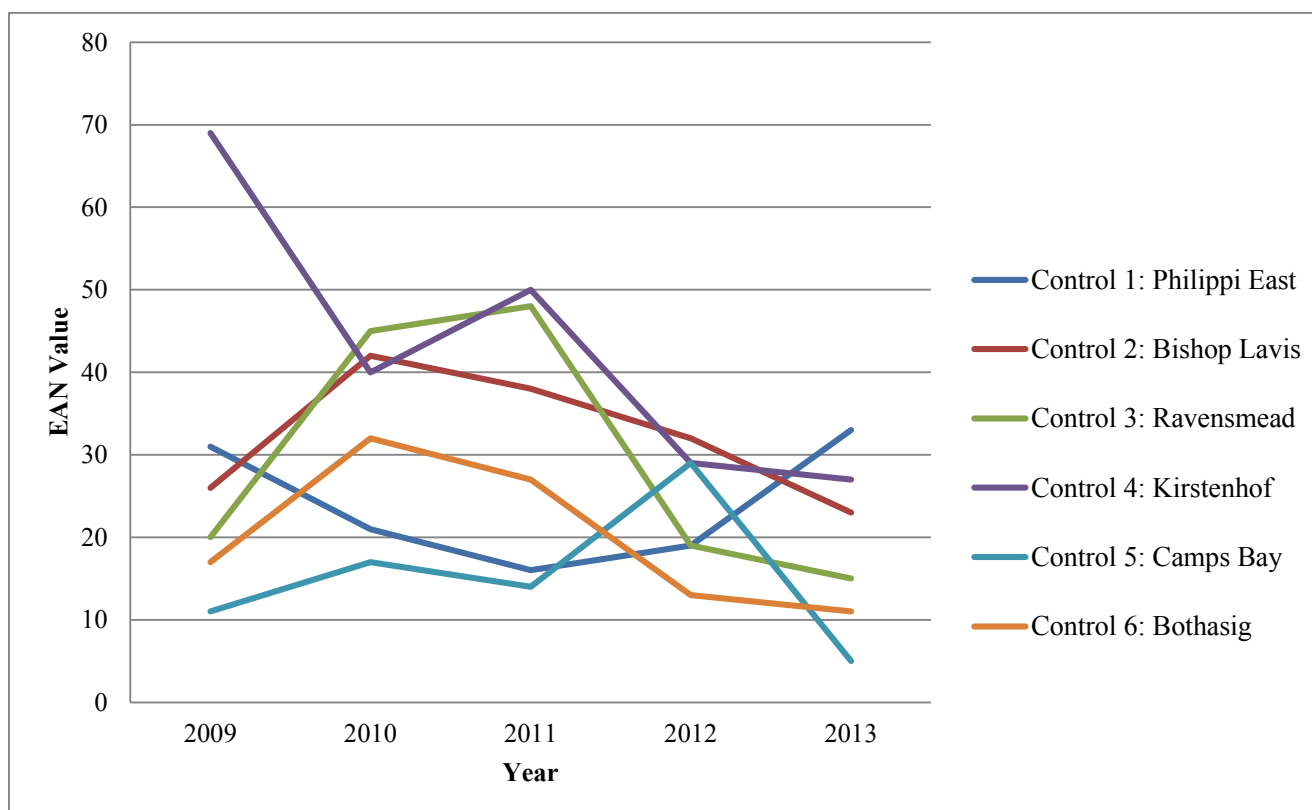


Figure 87: Cyclist Equivalent Accident Number of Control Areas

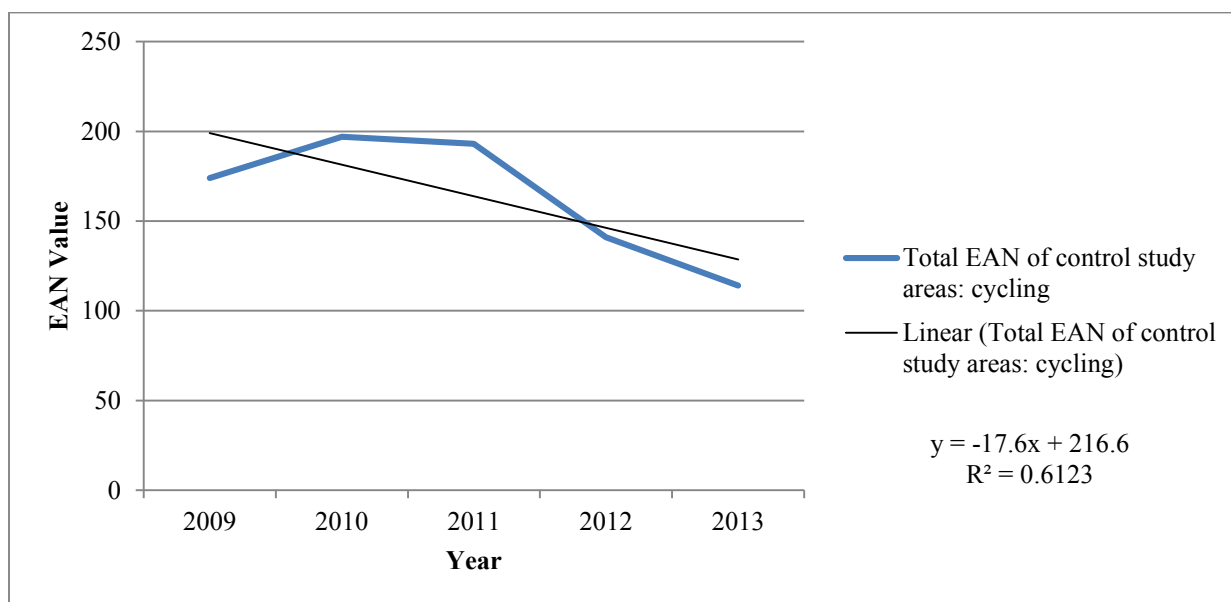


Figure 88: Total Cyclist Equivalent Accident Number of Control Areas

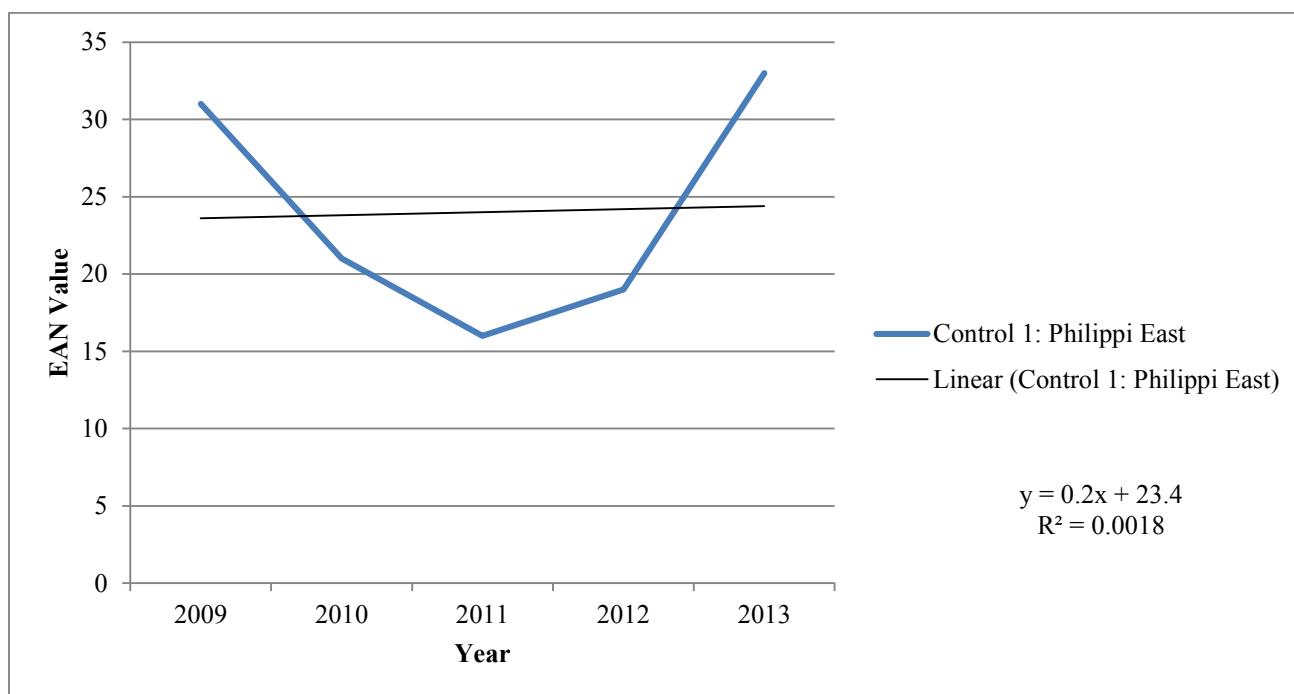


Figure 89: Cyclist Equivalent Accident Number of Philippi



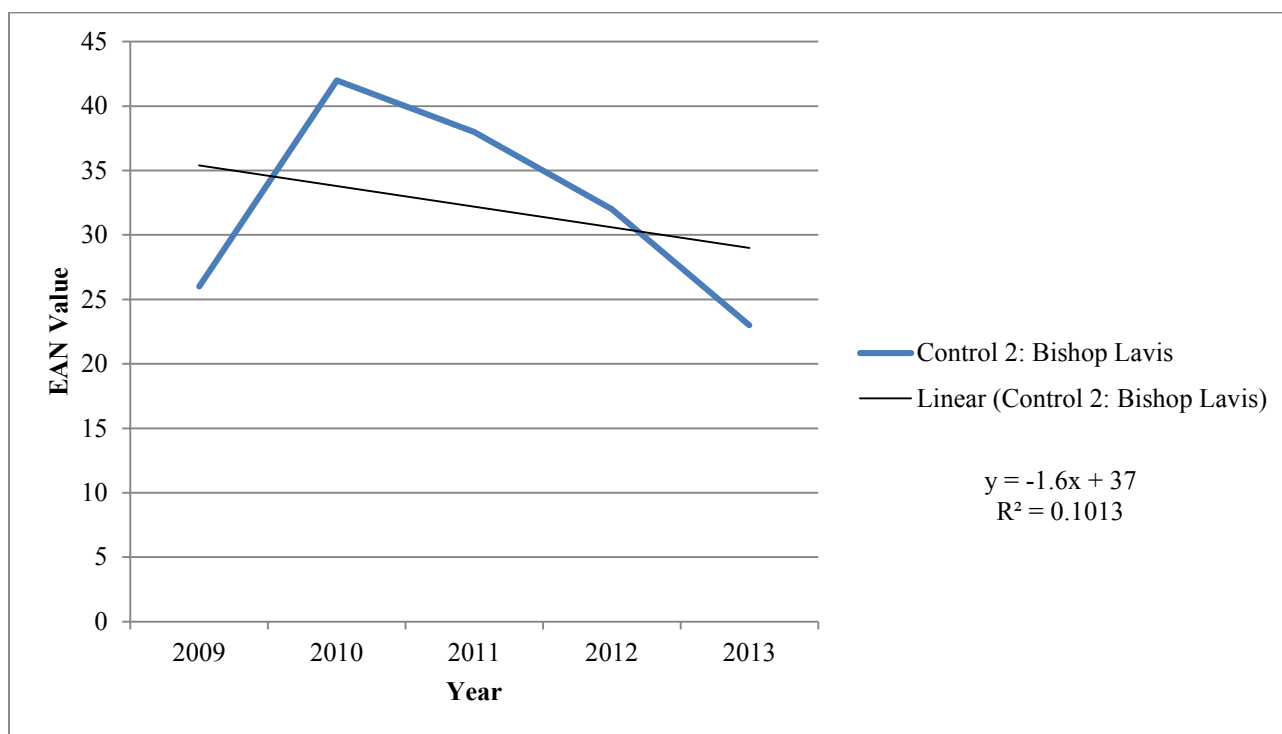


Figure 90: Cyclist Equivalent Accident Number of Bishop Lavis

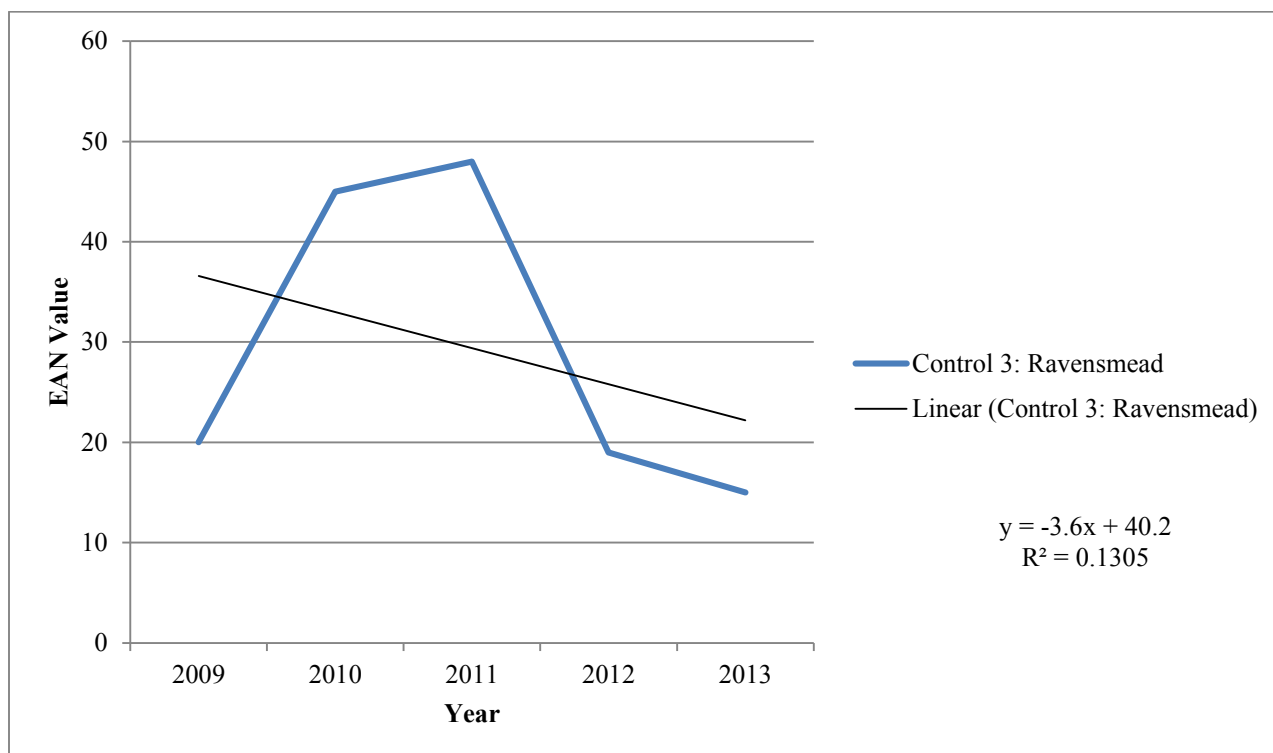


Figure 91: Cyclist Equivalent Accident Number of Ravensmead

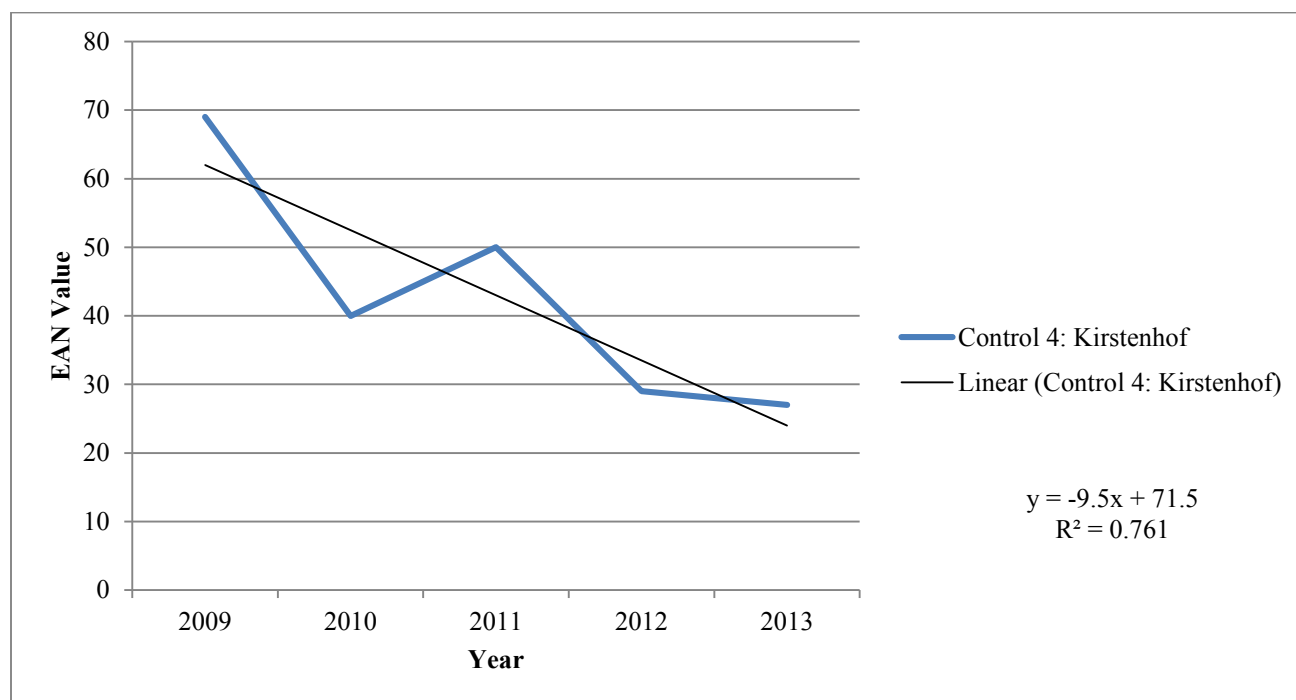


Figure 92: Cyclist Equivalent Accident Number of Ravensmead

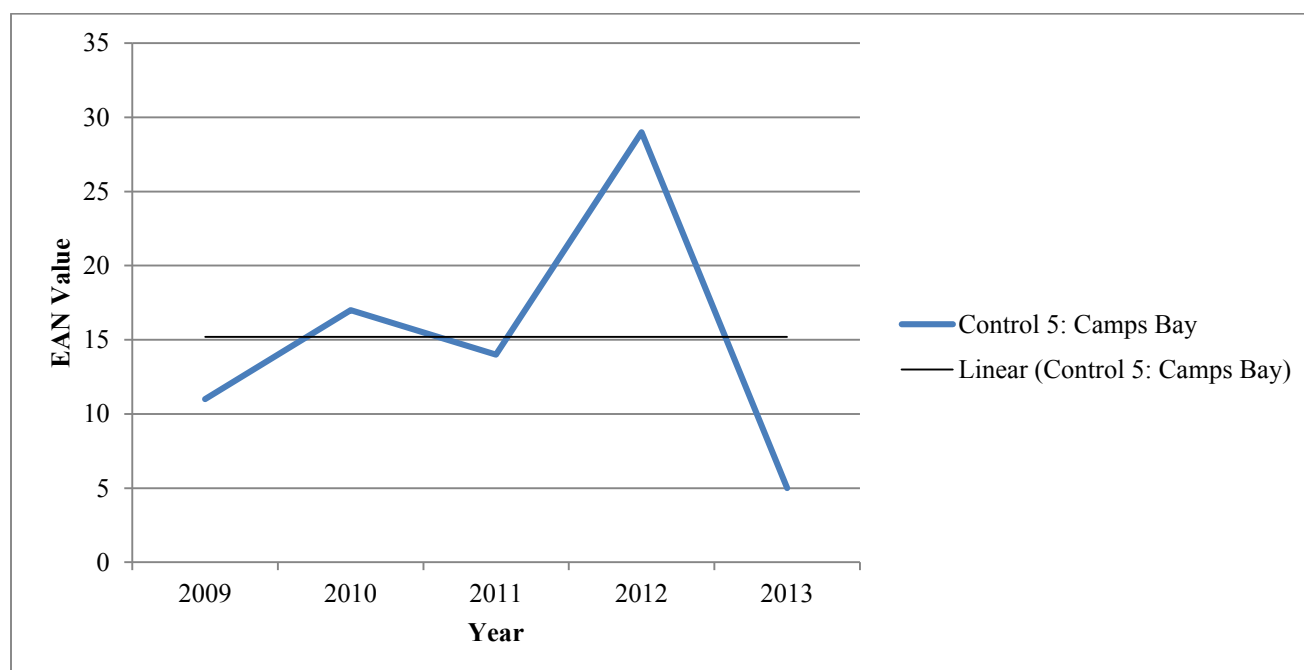


Figure 93: Cyclist Equivalent Accident Number of Camps Bay

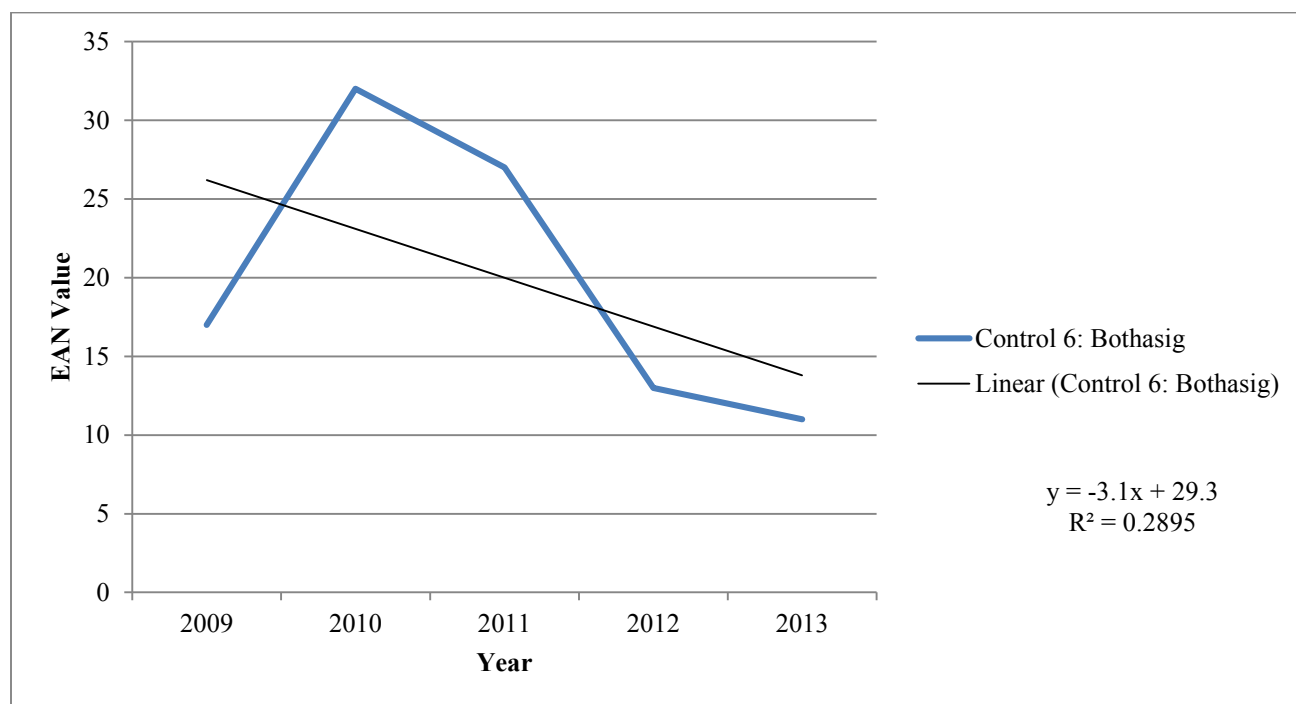


Figure 94: Cyclist Equivalent Accident Number of Bothasig

## APPENDIX D: T-TESTS

### D.1 PEDESTRIAN CASE STUDY VS CONTROL AREA

Table 17: T-Test for Pedestrian Case Study and Control Areas between 2008 and 2013

T Test: Two Independent Samples									
SUMMARY			Hyp Mean		0				
<i>Groups</i>	<i>Count</i>	<i>Mean</i>	<i>Variance</i>	<i>Cohen d</i>					
Total Control Areas	6	1728.667	28895.47						
Total Case Study Areas	6	5043	1171424						
Pooled			600159.9	4.278216					
T TEST: Equal Variances			Alpha		0.01				
	<i>std err</i>	<i>t-stat</i>	<i>df</i>	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>	<i>effect r</i>
One Tail	447.2732	7.410087	10	1.14E-05	2.763769			yes	0.919749
Two Tail	447.2732	7.410087	10	2.29E-05	3.169273	-4731.86	-1896.8	yes	0.919749
T TEST: Unequal Variances			Alpha		0.01				
	<i>std err</i>	<i>t-stat</i>	<i>df</i>	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>	<i>effect r</i>
One Tail	447.2732	7.410087	5.246519	0.000285	3.36493			yes	0.955398
Two Tail	447.2732	7.410087	5.246519	0.000571	4.032143	-5117.8	-1510.86	yes	0.955398

### D.2 PEDESTRIAN CASE STUDY AREAS

Table 18: T-Test for Atlantis for Implementations in 2012/13

1 EAN Atlantis 2012/13								
T Test: One Sample								
SUMMARY			Alpha		0.01			
Count	Mean	Std Dev	Std Err	t	df	Cohen d	Effect r	
4	443	91.100677	45.55033845	9.725504025	3	4.862752013	0.984508865	
T TEST								
			Hyp Mean		0			
	p-value	t-crit	lower	upper	sig			
One Tail	0.00115	4.5407029			yes			
Two Tail	0.00231	5.8409093	176.9446041	709.0553959	yes			

Table 19: T-Test for Langa for Implementations in 2011/13

2 EAN Langa 2011/13							
T Test: One Sample							
SUMMARY				Alpha		0.01	
Count	Mean	Std Dev	Std Err	t	df	Cohen d	Effect r
3	126.333	66.365151	38.31593808	3.297148384	2	1.903609507	0.919028934
T TEST							
				Hyp Mean		0	
	p-value	t-crit	lower	upper	sig		
One Tail	0.04049	6.9645567			no		
Two Tail	0.08097	9.9248432	-253.946344	506.6130109	no		

Table 20: T-Test for Gugulethu for Implementations in 2008/09 vs 2012/13

3 EAN Gugulethu 2008/09 vs 2012/13								
T Test: One Sample								
SUMMARY			Alpha		0.01			
Count	Mean	Std Dev	Std Err	t	df	Cohen d	Effect r	
2	715	181.01934	128	5.5859375	1	3.949854286	0.984350903	
T TEST			Hyp Mean		0			
	p-value	t-crit	lower	upper	sig			
One Tail	0.05639	31.820516			no			
Two Tail	0.11277	63.656741	-7433.06287	8863.062869	no			

Table 21: T-Test for Steenberg for Implementations in 2012/14

4 EAN Steenberg 2012/14							
T Test: One Sample							
SUMMARY		Alpha		0.01			
Count	Mean	Std Dev	Std Err	t	df	Cohen d	Effect r
4	345.25	36.673105	18.33655275	18.82851181	3	9.414255906	0.995795508
T TEST		Hyp Mean		0			
	p-value	t-crit	lower	upper	sig		
One Tail	0.00016	4.5407029			yes		
Two Tail	0.00033	5.8409093	238.1478583	452.3521417	yes		

Table 22: T-Test for Mitchells Plain for Implementations in 2012/13

5 EAN Mitchells Plain 2012/13							
T Test: One Sample							
SUMMARY			Alpha		0.01		
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
4	1454	132.3178	66.15889963	21.97739092	3	10.98869546	0.996908839
T TEST							
			Hyp Mean		0		
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.0001	4.5407029			yes		
Two Tail	0.00021	5.8409093	1067.571867	1840.428133	yes		



Table 23: T-Test for Dieprivier for Implementations in 2012/13

6 EAN Dieprivier 2012/13								
T Test: One Sample								
SUMMARY			Alpha		0.01			
Count	Mean	Std Dev	Std Err	t	df	Cohen d	Effect r	
4	149.75	21.85368	10.92684004	13.70478559	3	6.852392796	0.992108095	
T TEST			Hyp Mean		0			
	p-value	t-crit	lower	upper	sig			
One Tail	0.00042	4.5407029			yes			
Two Tail	0.00084	5.8409093	85.92731826	213.5726817	yes			

Table 24: T-Test for Khayelitsha for Implementations in 2008/09 vs 2012/13

7 EAN Khayelitsha 2008/09 vs 2012/13								
T Test: One Sample								
SUMMARY			Alpha		0.01			
Count	Mean	Std Dev	Std Err	t	df	Cohen d	Effect r	
2	351.5	13.435029	9.5	37	1	26.1629509	0.99963497	
T TEST								
			Hyp Mean		0			
	p-value	t-crit	lower	upper	sig			
One Tail	0.0086	31.820516			yes			
Two Tail	0.0172	63.656741	-253.239041	956.239041	no			

Table 25: T-Test for Sea Point for Implementations in 2008/09 vs 2012/13

8 EAN Sea Point    2008/09 vs 2012/13							
T Test: One Sample							
SUMMARY			Alpha		0.01		
Count	Mean	Std Dev	Std Err	t	df	Cohen d	Effect r
2	261.5	7.7781746	5.5	47.54545455	1	33.61971332	0.99977889
T TEST							
			Hyp Mean		0		
	p-value	t-crit	lower	upper	sig		
One Tail	0.00669	31.820516			yes		
Two Tail	0.01339	63.656741	-88.6120764	611.6120764	no		

Table 26: T-Test for CBD for Implementations in 2010/12

9 EAN CBD                      2010/12								
T Test: One Sample								
SUMMARY			Alpha		0.01			
Count	Mean	Std Dev	Std Err	t	df	Cohen d	Effect r	
2	1244	97.580736	69	18.02898551	1	12.74841791	0.998465288	
T TEST								
			Hyp Mean		0			
	p-value	t-crit	lower	upper	sig			
One Tail	0.01764	31.820516			no			
Two Tail	0.03527	63.656741	-3148.31514	5636.31514	no			

Table 27: T-Test for Milnerton for Implementations in 2011/12

10 EAN Milnerton 2011/12							
T Test: One Sample							
SUMMARY		Alpha		0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
4	666.75	83.168003	41.58400133	16.03381057	3	8.016905284	0.994215884
T TEST		Hyp Mean		0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.00026	4.5407029			yes		
Two Tail	0.00053	5.8409093	423.8616195	909.6383805	yes		

### D.3 PEDESTRIAN CONTROL AREAS

Table 28: T-Test for Philippi for Implementations in 2008/09 vs 2012/13

Control 1: Philip								
T Test: One Sample								
SUMMARY			Alpha		0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>	
2	558.5	48.7903679		34.5	16.188406	1	11.44693	0.998098
T TEST			Hyp Mean		0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>			
One Tail	0.0196379	31.82051595			no			
Two Tail	0.0392758	63.65674116	-1637.6576	2754.6576	no			

Table 29: T-Test for Bishop Lavis for Implementations in 2008/09 vs 2012/13

Control 2: Bishop Lavis							
T Test: One Sample							
SUMMARY				Alpha		0.01	
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
2	593	66.46803743	47	12.617021	1	8.921581	0.996874
T TEST				Hyp Mean		0	
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.025176	31.82051595			no		
Two Tail	0.050352	63.65674116	-2398.8668	3584.8668	no		

Table 30: T-Test for Ravensmead for Implementations in 2008/09 vs 2012/13

Control 3: Ravensmead							
T Test: One Sample							
SUMMARY				Alpha		0.01	
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
2	372	15.55634919	11	33.818182	1	23.91307	0.999563
T TEST				Hyp Mean		0	
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.0094096	31.82051595			yes		
Two Tail	0.0188193	63.65674116	-328.22415	1072.2242	no		

Table 31: T-Test for Kirstenhof for implementations in 2008/09 vs 2012/13

Control 4: Kirstenhof								
T Test: One Sample								
SUMMARY			Alpha		0.01			
Count	Mean	Std Dev	Std Err	t	df	Cohen d	Effect r	
2	124.5	28.99137803	20.5	6.0731707	1	4.29438	0.986713	
T TEST								
			Hyp Mean		0			
	p-value	t-crit	lower	upper	sig			
One Tail	0.0519464	31.82051595			no			
Two Tail	0.1038927	63.65674116	-1180.4632	1429.4632	no			

Table 32: T-Test for Camps Bay for implementations in 2008/09 vs 2012/13

Control 5: Camps Bay								
T Test: One Sample								
SUMMARY			Alpha		0.01			
Count	Mean	Std Dev	Std Err	t	df	Cohen d	Effect r	
3	34	3.464101615	2	17	2	9.814955	0.996558	
T TEST			Hyp Mean		0			
	p-value	t-crit	lower	upper	sig			
One Tail	0.0017212	6.964556734			yes			
Two Tail	0.0034424	9.924843201	14.1503136	53.849686	yes			

Table 33: T-Test for Bothasig for implementations in 2008/09 vs 2012/13

Control 6: Bothasig T Test: One Sample							
SUMMARY				Alpha	0.01		
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
2	75	7.071067812	5	15	1	10.6066	0.997785
T TEST				Hyp Mean	0		
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.0211893	31.82051595			no		
Two Tail	0.0423786	63.65674116	-243.28371	393.28371	no		

#### D.4 CYCLIST CASE STUDY VS CONTROL AREA

Table 34: T-Test for Cyclist Case Study and Control Areas from 2009 to 2013

T Test: Two Independent Samples									
SUMMARY			Hyp Mear	0					
<i>Groups</i>	<i>Count</i>	<i>Mean</i>	<i>Variance</i>	<i>Cohen d</i>					
Total	5	257.2	2433.2						
Total	5	163.8	1264.7						
Pooled			1848.95	2.172122					
T TEST: Equal Variances				Alpha	0.01				
	<i>std err</i>	<i>t-stat</i>	<i>df</i>	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>	<i>effect r</i>
One Tail	27.19522	3.434427	8	0.004448	2.896459			yes	0.771922
Two Tail	27.19522	3.434427	8	0.008897	3.355387	2.149503	184.6505	yes	0.771922
T TEST: Unequal Variances				Alpha	0.01				
	<i>std err</i>	<i>t-stat</i>	<i>df</i>	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>	<i>effect r</i>
One Tail	27.19522	3.434427	7.273721	0.005145	2.997952			yes	0.786485
Two Tail	27.19522	3.434427	7.273721	0.010291	3.499483	-1.76922	188.5692	no	0.786485

## D.5 CYCLIST CASE STUDY AREAS

Table 35: T-Test for Atlantis for Implementations in 2012/13

1 EAN Atlantis Cyclist								
T Test: One Sample								
SUMMARY			Alpha		0.01			
Count	Mean	Std Dev	Std Err	t	df	Cohen d	Effect r	
3	25	6	3.464102	7.216878	2	4.166667	0.981336	
T TEST			Hyp Mean		0			
	p-value	t-crit	lower	upper	sig			
One Tail	0.009332	6.964557			yes			
Two Tail	0.018664	9.924843	-9.38067	59.38067	no			

Table 36: T-Test for Langa for Implementations in 2011/13

2 EAN Langa Cyclist							
T Test: One Sample							
SUMMARY			Alpha	0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
2	13.5	2.12132	1.5	9	1	6.363961	0.993884
T TEST			Hyp Mear	0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.035223	31.82052			no		
Two Tail	0.070447	63.65674	-81.9851	108.9851	no		



Table 37: T-Test for Gugulethu for Implementations in 2009/10 vs 2012/13

3 EAN Gugulethu Cyclist								
T Test: One Sample								
SUMMARY			Alpha		0.01			
Count	Mean	Std Dev	Std Err	t	df	Cohen d	Effect r	
2	5	2.828427	2	2.5	1	1.767767	0.928477	
T TEST								
			Hyp Mear		0			
	p-value	t-crit	lower	upper	sig			
One Tail	0.121119	31.82052			no			
Two Tail	0.242238	63.65674	-122.313	132.3135	no			

Table 38: T-Test for Steenberg for Implementations in 2012/14

4 EAN Steenberg Cyclist							
T Test: One Sample							
SUMMARY			Alpha		0.01		
Count	Mean	Std Dev	Std Err	t	df	Cohen d	Effect r
3	47.66667	4.50925	2.603417	18.30927	2	10.57086	0.99703
T TEST			Hyp Mean		0		
	p-value	t-crit	lower	upper	sig		
One Tail	0.001485	6.964557			yes		
Two Tail	0.00297	9.924843	21.82817	73.50517	yes		

Table 39: T-Test for Mitchells Plain for Implementations in 2012/13

5 EAN Mitchells Plain Cyclist							
T Test: One Sample							
SUMMARY		Alpha		0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
3	67.6667	9.29	5.364492	12.61381	2	7.282584	0.993774
T TEST		Hyp Mear		0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.0031	6.96			yes		
Two Tail	0.0062	9.92	14.42492	120.9084	yes		

Table 40: T-Test for Dieprivier for Implementations in 2012/13

6 EAN Dieprivier Cyclist							
T Test: One Sample							
SUMMARY		Alpha		0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
3	34.66667	4.041452	2.333333	14.85714	2	8.577775	0.9955
T TEST		Hyp Mean		0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.00225	6.964557			yes		
Two Tail	0.0045	9.924843	11.5087	57.82463	yes		

Table 41: T-Test for Khayelitsha for Implementations in 2009/10 vs 2012/13

7 EAN Khayelitsha Cyclist							
T Test: One Sample							
SUMMARY		Alpha		0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
2	18	2.828427	2	9	1	6.363961	0.993884
T TEST		Hyp Mean		0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.035223	31.82052			no		
Two Tail	0.070447	63.65674	-109.313	145.3135	no		

Table 42: T-Test for Sea Point for Implementations in 2009/10 vs 2012/13

8 EAN Sea Point Cyclist							
T Test: One Sample							
SUMMARY		Alpha		0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
2	13.5	3.535534	2.5	5.4	1	3.818377	0.983282
T TEST		Hyp Mean		0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.058286	31.82052			no		
Two Tail	0.116572	63.65674	-145.642	172.6419	no		

Table 43: T-Test for CBD for Implementations in 2010/12

9 EAN CBD Cyclist							
T Test: One Sample							
SUMMARY		Alpha		0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
2	12.5	0.707107	0.5	25	1	17.67767	0.999201
T TEST		Hyp Mean		0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.012726	31.82052				no	
Two Tail	0.025451	63.65674	-19.3284	44.32837		no	

Table 44: T-Test for Milnerton for Implementations in 2011/12

10 EAN Milnerton Cyclist							
T Test: One Sample							
SUMMARY		Alpha		0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
2	43.5	2.12132	1.5	29	1	20.5061	0.999406
T TEST		Hyp Mean		0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.010972	31.82052				no	
Two Tail	0.021944	63.65674	-51.9851	138.9851		no	

## D.6 CYCLIST CONTROL AREAS

Table 45: T-Test for Philippi for Implementations in 2009/10 vs 2012/13

Control 1: Philip Cyclist							
T Test: One Sample							
SUMMARY			Alpha	0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
2	26.0000	7.07	5	5.2	1	3.676955	0.982006
T TEST							
			Hyp Mean	0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.0605	31.82			no		
Two Tail	0.1210	63.66	-292.2837	344.2837	no		

Table 46: T-Test for Bishop Lavis for Implementations in 2009/10 vs 2012/13

Control 2: Bishop Lavis Cyclist								
T Test: One Sample								
SUMMARY			Alpha		0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>	
2	34	11.31371	8	4.25	1	3.005204	0.973417	
T TEST								
			Hyp Mear		0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>			
One Tail	0.073558	31.82052			no			
Two Tail	0.147117	63.65674	-475.254	543.2539	no			

Table 47: T-Test for Ravensmead for Implementations in 2009/10 vs 2012/13

Control 3: Ravensmead Cyclist								
T Test: One Sample								
SUMMARY			Alpha		0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>	
2	32.5	17.67767	12.5	2.6	1	1.838478	0.933346	
T TEST								
			Hyp Mear.		0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>			
One Tail	0.116875	31.82052			no			
Two Tail	0.23375	63.65674	-763.209	828.2093	no			

Table 48: T-Test for Kirstenhof for Implementations in 2009/10 vs 2012/13

Control 4: Kirstenhof Cyclist								
T Test: One Sample								
SUMMARY			Alpha		0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>	
2	54.5	20.5061	14.5	3.758621	1	2.657746	0.966382	
T TEST								
			Hyp Mear		0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>			
One Tail	0.082771	31.82052			no			
Two Tail	0.165541	63.65674	-868.523	977.5227	no			

Table 49: T-Test for Camps Bay for Implementations in 2009/10 vs 2012/13

Control 5: Camps Bay Cyclist							
T Test: One Sample							
SUMMARY		Alpha		0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
2	14	4.242641	3	4.666667	1	3.299832	0.977802
T TEST		Hyp Mear		0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.067193	31.82052				no	
Two Tail	0.134386	63.65674	-176.97	204.9702		no	

Table 50: T-Test for Bothasig for Implementations in 2009/10 vs 2012/13

Control 6: Bothasig Cyclist							
T Test: One Sample							
SUMMARY		Alpha		0.01			
<i>Count</i>	<i>Mean</i>	<i>Std Dev</i>	<i>Std Err</i>	<i>t</i>	<i>df</i>	<i>Cohen d</i>	<i>Effect r</i>
2	24.5	10.6066	7.5	3.266667	1	2.309882	0.9562
T TEST		Hyp Mear		0			
	<i>p-value</i>	<i>t-crit</i>	<i>lower</i>	<i>upper</i>	<i>sig</i>		
One Tail	0.094558	31.82052				no	
Two Tail	0.189117	63.65674	-452.926	501.9256		no	



## APPENDIX E: LOCATIONS OF SELECTED AREAS FOR CASE STUDY INFRASTRUCTURE ASSESSMENTS

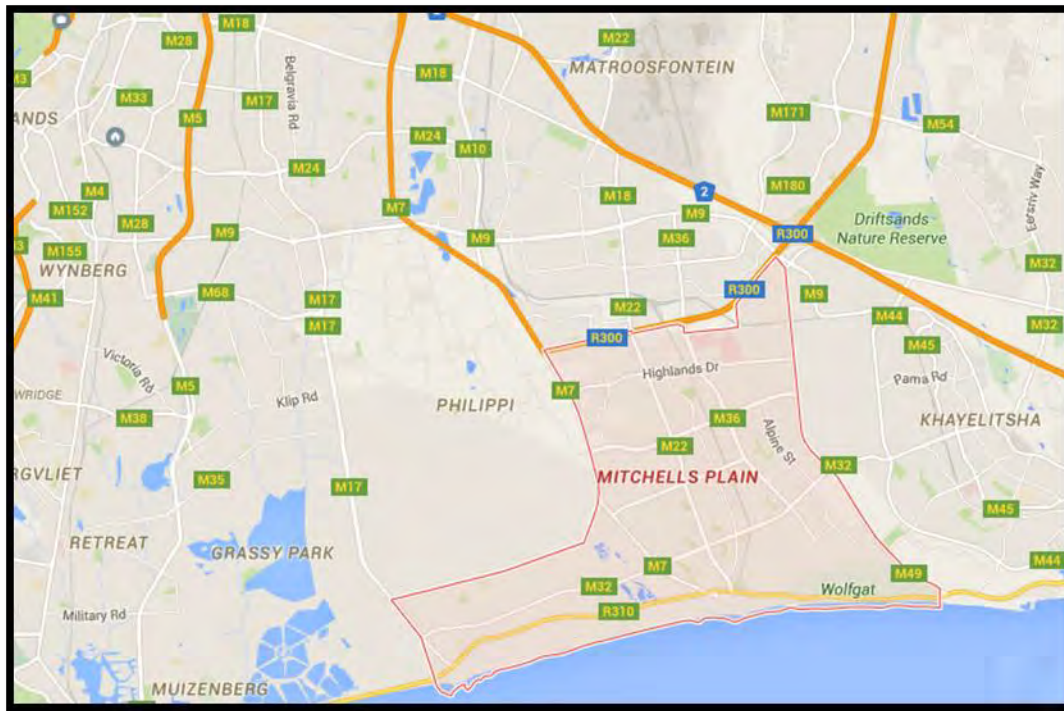


Figure 95: Location of the Case Study Area of Mitchells Plain, with the Control Area of Philippi Adjacent (Source: Google Maps)

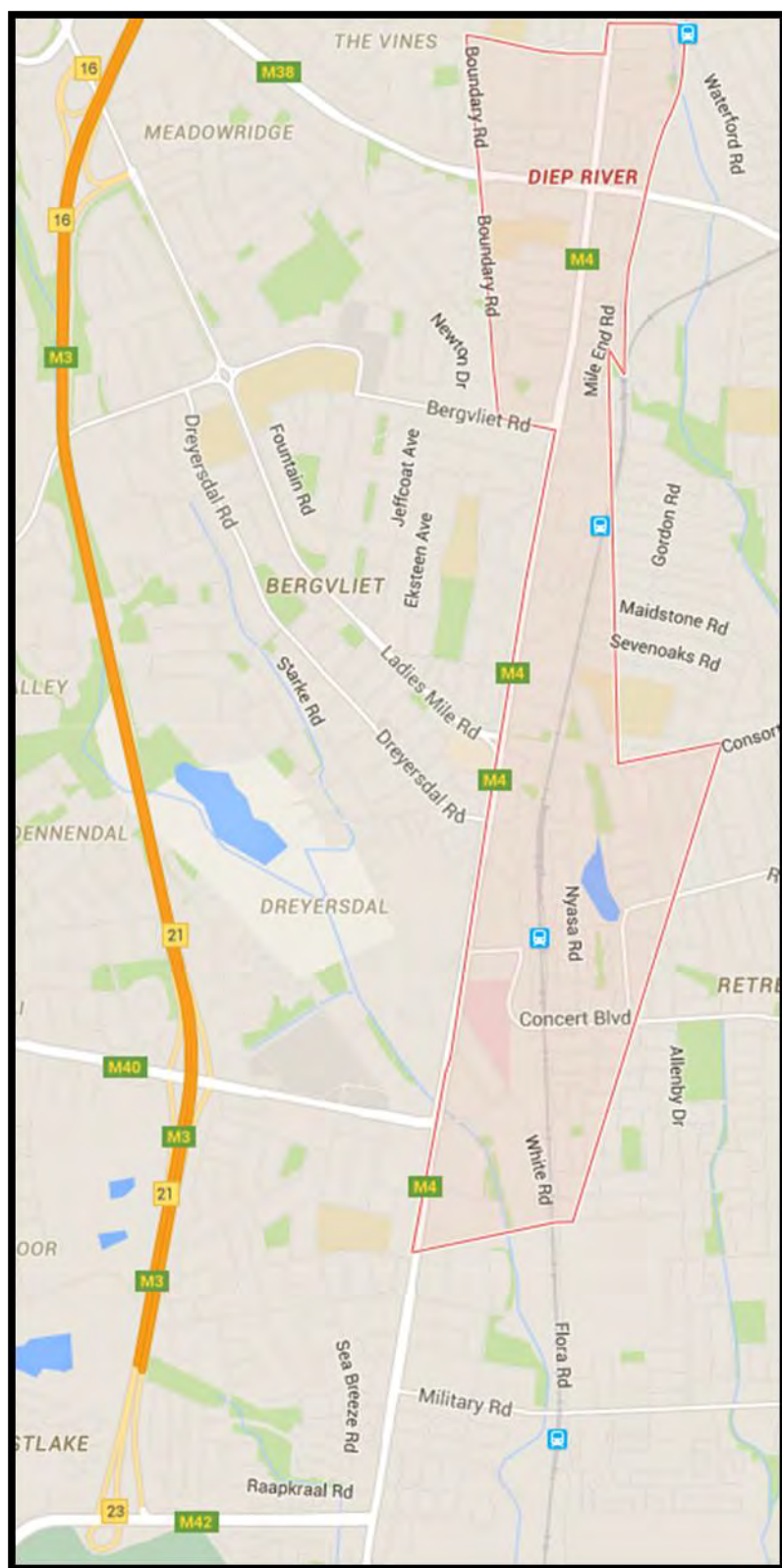


Figure 96: Location of Case Study Area Diepriver (Source: Google Maps)

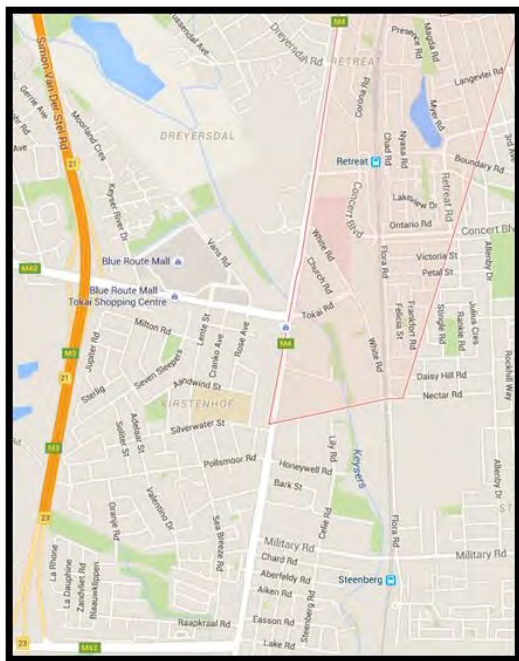


Figure 97: South Section of Case Study Area Dieprivier Showing Area of Control Area Kirstenhof (Source: Google Maps)

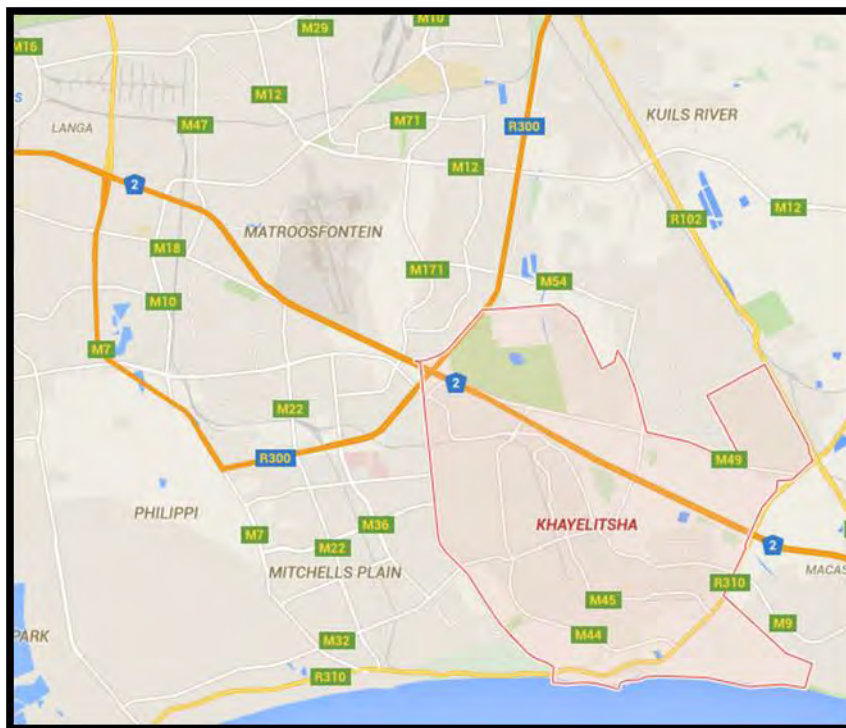


Figure 98: Location of Case Study Area Khayelitsha with Control Area Philippi (Source: Google Maps)





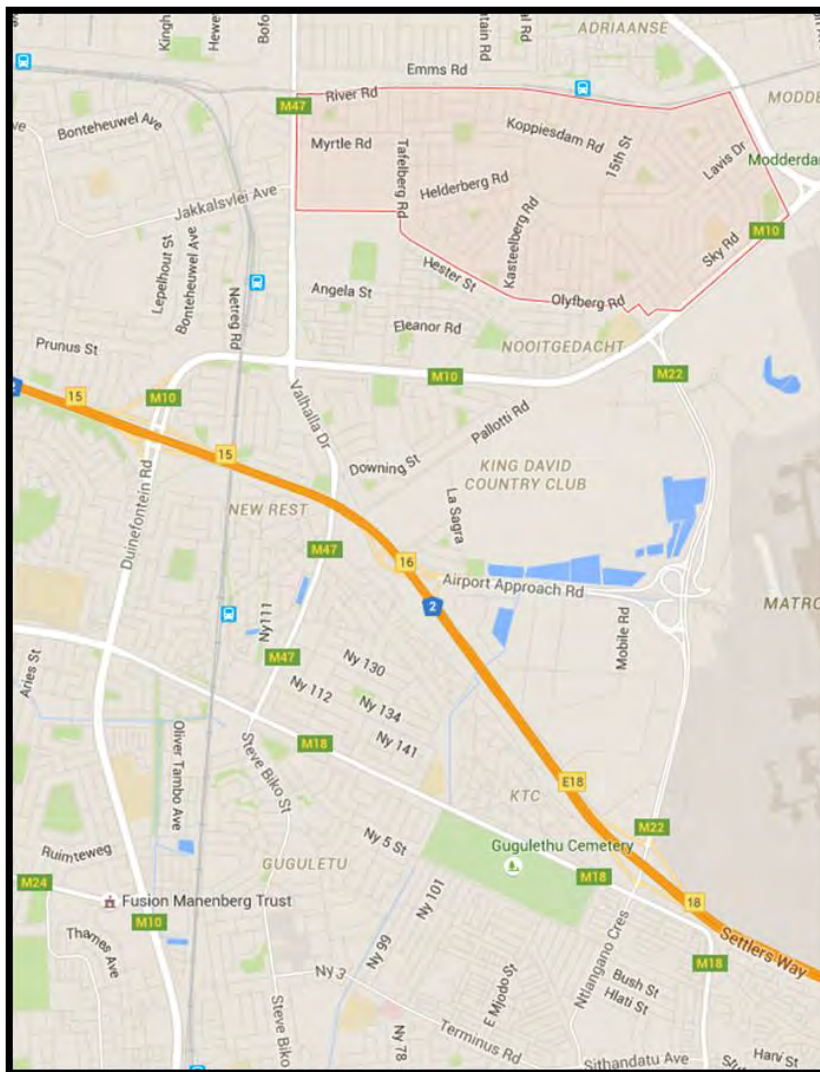


Figure 101: Control Area Bishop Lavis with Case Study Area of Gugulethu (Source: Google Maps)

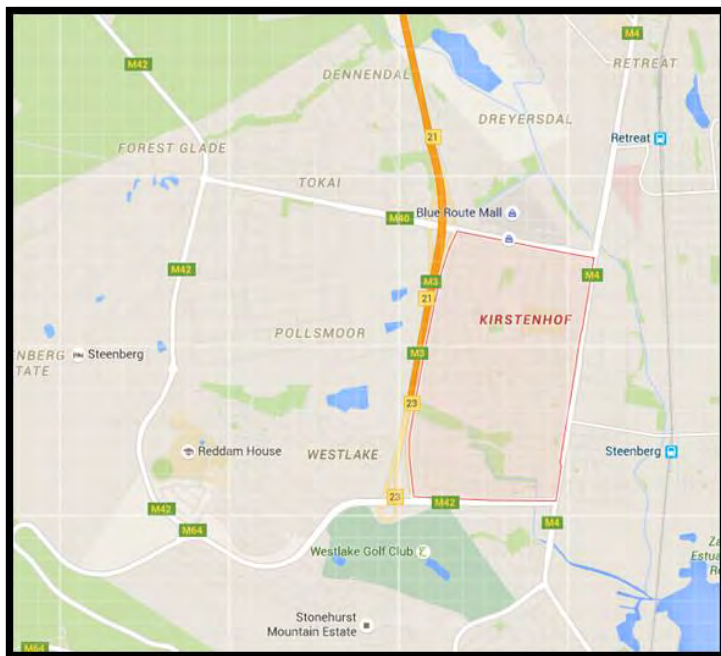


Figure 102: Location of Control Area Kirstenhof, Situated South of Case Study Area Dieprivier (Source: Google Maps)

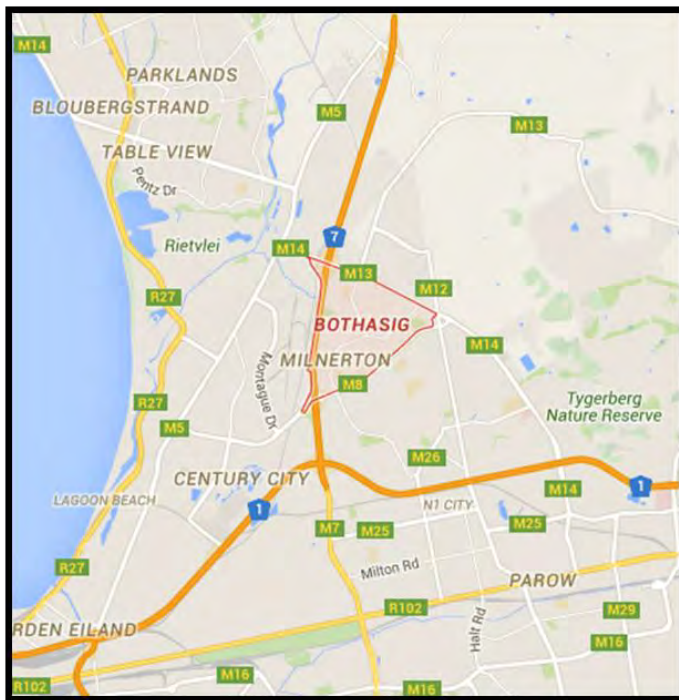


Figure 103: Location of Control Area Bothasig (Source: Google Maps)

## APPENDIX F: ETHICS FORM

Ethics clearance was completed through the online system. Copy of the hardcopy form is shown below.

**EBE Faculty: Assessment of Ethics in Research Projects**

Any person planning to undertake research in the Faculty of Engineering and the Built Environment at the University of Cape Town is required to complete this form before collecting or analysing data. When completed it should be submitted to the supervisor (where applicable) and from there to the Head of Department. If any of the questions below have been answered YES, and the applicant is NOT a fourth-year student, the Head should forward this form for approval by the Faculty EIR committee; submit to Ms Zakiya Chikile (Zakiya.chikile@uct.ac.za), New EBE Building, Ph 021 680 57350. Students must include a copy of the completed form with the dissertation/thesis when it is submitted for completion.

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**Name of Principal Researcher/Student:** Jennifer Louise Baufeldt **Department:** Civil Engineering Transport Studies

**If a Student:** Degree: MSc Civil Engineering Transport Studies **Supervisor:** Marienne Vanderschuren

**If a Research Contract indicate source of funding/sponsorship:** Southern Centre of Transport

**Research Project Title:** An investigation into the effects of increased levels of NMT facilities in South Africa

**Overview of ethics issues in your research project:**

Question 1: Is there a possibility that your research could cause harm to a third party (i.e. a person not involved in your project)?	YES	NO X
Question 2: Is your research making use of human subjects as sources of data? If your answer is YES, please complete Addendum 2.	YES X	NO
Question 3: Does your research involve the participation of or provision of services to communities? If your answer is YES, please complete Addendum 3.	YES	NO X
Question 4: If your research is sponsored, is there any potential for conflicts of interest? If your answer is YES, please complete Addendum 4.	YES	NO X

If you have answered YES to any of the above questions, please append a copy of your research proposal, as well as any interview schedules or questionnaires (Addendum 1) and please complete further addenda as appropriate.

**I hereby undertake to carry out my research in such a way that**

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

**Signed by:**

	Full name and signature	Date
Principal Researcher/Student:	Jennifer Louise Baufeldt 	29 <sup>th</sup> September 2015

**This application is approved by:**

Supervisor (if applicable):	Prof. Marienne Vanderschuren 	29/11/15
HOD (or delegated nominee): Final authority for all assessments with NO to all questions and for all undergraduate research.		
Chair: Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the above questions.	Dr. S. H. ... 	10/11/2015