RAT-RUNNING THROUGH WALMER ESTATE, UNIVERSITY ESTATE AND UPPER WOODSTOCK DURING THE PM PEAK PERIOD

END 5017Z - Minor Dissertation

13 May 2016

Prepared by: **Adrian Joshua Tarrant**
Student number: **TRRADR001**

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Submitted as part of my MEng: Transport Studies degree

CENTRE FOR TRANSPORT STUDIES
Faculty of Engineering and the Built Environment

University of Cape Town • iYunivesithi yaseKapa • Universiteit van Kaapstad

DEDICATION

This dissertation is submitted as the final component of my MEng: Transport Studies degree. For the past four years I have been working part-time towards the completion of this degree, offered through the Centre of Transport Studies at the University of Cape Town. Unlike the rest of the course work associated with the completion of this degree, the dissertation has demanded prolonged periods of focus and dedication I admit that I, at times, have struggled to maintain the motivation required.

I would like to extend my gratitude to my supervisor, Marianne Vanderschuren, who provided valuable insight and guidance throughout this process. I may have flown under-the-radar at times and I think at some points you wondered if I was still registered, but I appreciate the time that you set aside to assist me.

Lastly, thank you to Casey-Jade Yee for helping me retain my motivation and focus while trying to juggle all of my many responsibilities during this time.

STUDENT'S DECLARATION

I declare that this dissertation is my own, unaided work and is submitted as part of the MEng: Transport Studies degree at the University of Cape Town. It has not been submitted before for any degree or examination at any other University.

I know the meaning of plagiarism and declare that all the work in the document, save for that which is properly acknowledged, is my own.

Signed by candidate

Adrian Tarrant

13th May 2016

EXECUTIVE SUMMARY

Introduction and Background

Urban sprawl remains as a remnant of previous Apartheid legacy policies and has a daily impact on the majority of South African commuters: large, densely populated residential areas (i.e. informal settlements) are generally located on the periphery of towns or cities, far away from areas of employment. As a result, a large number of commuters have to travel great distances to-and from work on a daily basis, and those making use of private vehicles have to accept very high levels of congestion for a large part of their journey. Certain motorists, therefore, carefully select routes, in an attempt to bypass some of this congestion experienced on the arterials and highways, to minimise their travel time and many times this is achieved through the practice of rat-running.

This minor dissertation proposes to quantify the number of rat-runners and to identify the routes that the motorists use when moving through a pre-defined study area, with a view towards developing an effective solution to this problem. To achieve this, it is necessary to explore the root causes behind rat-running and investigate what has been done elsewhere to, successfully, mitigate this problem. This information was used to derive a number of proposed mitigating measure alternatives, applicable to the study area's current rat-running where, after a final decision, a preferred solution and the way forward was established.

Problem Description

The existing Cape Town CBD is positioned in a unique location: the topography of the City, i.e. the position of Table Mountain (and other mountain ranges) and the Atlantic Sea (coastline) means that the majority of the population lives to the east of the CBD, with very few residential opportunities available to the west**.** As such, there are a limited number of road-based routes to access and exit the City's Central CBD, to and from these east-lying areas which results in significant peak period congestion issues on the City's road network. In fact, results from a study undertaken by GPS manufacturer Tomtom (2014) show that the Cape Town road network is the most congested in the country.

It is anticipated that the above-mentioned conditions make it attractive/possible for vehicles leaving the CBD during the PM peak period to rat-run through the immediately adjacent suburban areas, in an attempt to bypass the excessive levels of congestion currently experienced on the major routes. This practice creates major health, safety and economic problems for the affected communities and is a cause for major unhappiness as a result of the associated deterioration in their overall quality of life.

Literature Review

The research explains that the building of new road infrastructure to create additional capacity does not reduce the level of congestion experienced, but merely unlocks latent demand, resulting in an upgraded road network experiencing similar levels of congestion as before. As such, motorists search for alternative solutions to the congestion problem, in an attempt to decrease travel times, with one of these alternatives being rat-running.

All drivers use varying amounts of information to inform their route choice on a particular journey, though this information could either be quantifiable (e.g. travel times) or subjective (e.g. potential losses) depending on the psychology of the driver. It is, however, possible to effect a change in a driver's route choice by applying some form of "trigger" (e.g. traffic fine, implementation of traffic calming measures along a chosen route, etc) although motorists will strive to find the shortest route between origin and destination, with network equilibrium occurring when no motorist can decrease travel effort by shifting to a new route.

Land use planning plays an important role in traveller behaviour as it is formally used to influence travel patterns and the transport network through zoning and there are a variety of benefits and disbenefits associated with incorrect land use planning. Unfortunately, the City of Cape Town (and the majority of South African cities) is characterised by urban sprawl as a result of previous legacy policies, which mainly has a negative effect on the City's transport network. This City is, however, attempting to correct this through the implementation of a long term transit-oriented development (TOD) approach, which is expected to produce a number of benefits including increased land values, reduced per capita motor vehicle travel etc. and this is expected to have a mitigating effect on rat-running. In addition, the proposed redevelopment of District Six is expected to have a significant impact on traffic on the road network within the immediate vicinity of the study area. The addition of traffic to the road network, creation of new accesses (roads/intersections) and the proposal to change the cross-section of a key road (Keizersgracht) to favour public transport (and incorporate all modes) is expected to have a mitigating effect on the current rat-runners travelling through the study area.

The above-mentioned measures are, however, considered medium-to long term measures (based on an overall pragmatic assessment as opposed to a calculation) as a result of the time taken for implementation and for their intended effects to be realised. There are certain short-term measures (i.e. short lead time for implementation) that can be implemented to mitigate the effect of rat-runners and these include vertical deflection measures (e.g. speed humps), horizontal deflection measures (e.g. chicanes), holistic

measures (e.g. woonerf treatments) or measures, such as ramp metering. All of the above measures have various advantages, disadvantages and constraints associated with their implementation and these need to be considered (specific to the proposed implementation site) before a decision is made.

The City has attempted to mitigate the rat-run problem in consultation with the affected community. The chosen solution was, unfortunately not successful, as it relied on daily traffic enforcement to ensure compliance, which was not achieved. In addition to this measure, 16 traffic calming measures have been implemented within the study area in the past and seem to have little effect in mitigating the rat-running problem.

Survey Methodology and Results

A vehicle number plate recognition survey was undertaken at key locations along the perimeter of the study area to quantify the number of rat-runners travelling through the study area during the PM peak period (16:00 to 18:00). The survey tracked motorists using four different rat-run routes.

The results of the survey showed that approximately 1 300 vehicles entered the study area during the two hour survey period with more than 700 vehicles using one of the four surveyed routes. More than 90% of these vehicles were recorded entering the study area via Keizersgracht and although all four routes were, generally, well utilised, the majority of rat-runners made use of the De Waal Drive exit. Furthermore, an assessment of the environmental capacity of certain roads within the study area revealed that these roads were operating well in excess of the accepted threshold, which is significant concern.

Proposed Mitigating Measures

Various lead times are associated with the different types of mitigating measures and it was, therefore, decided to select separate short-term and medium-to-long term mitigating measures. The short-term measures should be viewed as an interim solution to the existing problem with the intention that the medium-to long term solutions take over when implemented.

The City's TOD-based planning approach and the proposed redevelopment of District Six are both expected to have a major impact on traveller behaviour and the road network immediately surrounding the proposed development. This anticipated impact is considered sufficient to mitigate the effects of the rat-runners travelling through the study area in the medium and medium-to-long-term (i.e. once District Six is fully redeveloped and a number of the City's TOD-based policies are realised).

A number of possible short-term measures were selected based on a set of criteria that were identified as being critical to the efficacy of these measures. The alternatives were:

- The construction of barriers at key intersections, to prevent rat-runners from performing their required movements to complete their rat-run ("Alternative 1").
- A woonerf-style treatment applied to all the roads within the study area ("Alternative 2").
- The construction of ramp metering at key locations to control the number of vehicles accessing the external road network during specific periods ("Alternative 3").

A multi-criteria analysis (scorecard method) was undertaken using the above-mentioned criteria to determine the preferred alternative and the results are summarised in **Table I**.

Table I: Summary of MCA Results for Proposed Mitigating Measures

Criterion	Weighting (Importance)	Alternative		
		1	2	3
Cost	0,1	1	0,4	0,5
Enforcement	0,25	0	1	1
Accessibility	0,25	0,2	1	1
Maximum Diversion Length	0,05	0,5	1	1
Effect on Surrounding Road Network	0,05	-1	0	1
Implementation Time	0,3	1	0,25	0,5
	Total	0,425	0,665	**0,8**

The emphasis of this analysis was based on criteria that will ensure the overall efficacy of a measure, as opposed to criteria that are merely indicators related to traffic flow (i.e. delay, etc.). The results of the analysis summarised in **Table I** show the ramp meters measure (Alternative 3) to be the mostly likely effective short-term measure for the study area's current rat-running problem.

The Way Forward

It is recommended that additional modelling studies are undertaken to understand the overall effect that the implementation of ramp metering at the indicated locations will have on the surrounding road network (and rat-run volumes) before making a final decision regarding implementation.

It is also important to remember that the recommended medium-to-long term measures will remain the redevelopment of District Six and the outcome of the City's TOD-based planning approach.

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1 INTRODUCTION

1.1 Background

Rat-running is defined as the practice of using secondary roads or residential side streets instead of the intended main roads in urban and suburban areas in an attempt to avoid traffic congestion (*Oxford Dictionaries*, 2015). Although difficult to prevent, this practice has damaging effects on the affected communities. Safety, health and quality of life is often compromised, due to the increase in vehicular volumes making use of these routes and in some cases, the value of the properties within the area are negatively affected.

Urban sprawl remains as a remnant of previous Apartheid legacy policies and has a daily impact on the majority of South African commuters: the large, densely populated residential areas (i.e. informal settlements) are, generally, located on the periphery of towns or cities far, away from areas of employment. As a result, a large number of commuters have to travel great distances to and from work on a daily basis, and those making use of private vehicles have to contend with very high levels of congestion for a large part of their journey. Certain motorists, therefore, carefully select routes, in an attempt to bypass some of this congestion experienced on the arterials and highways, to minimise their travel time and many times this is achieved through the practice of rat-running.

This paper proposes to present viable solutions (for further investigation) to an existing rat-running problem within a specified study area, by establishing and exploring the root causes of rat-running, both in a general sense and specific to the study area. The role that land use planning has on traveller behaviour will be established; with a focus on what the City of Cape Town has adopted as their long term planning approach, what has been planned for the study area and surrounds and what the associated transport-related effects of this will be. The efficacy of different types of rat-run mitigating measures will be investigated and comment will be provided regarding the measures that have previously been implemented within the study area (and the efficacy of these). Various other factors that may influence traveller behaviour will be also examined. A case study will then be undertaken in an attempt to quantify the number of rat-runners making use of certain routes through the study area (Walmer Estate).

The above information will then be used to determine a proposed preferred solution (for further investigation) to the rat-running problem within the study area. The report will conclude with a set of recommendations regarding the way forward.

1.2 Problem Description

The existing Cape Town CBD is positioned in a unique location: the topography of the City, i.e. the position of Table Mountain (and other mountain ranges) and the Atlantic Sea (coastline) means that the majority of the population lives to the east of the CBD, with very few residential opportunities available to the west, as shown in **Figure 1.1**. The figure also shows that as Cape Town is a developing port city, its movement system is predominantly radial in nature although, over time, it has become more of a grid system.

This is further highlighted in the City of Cape Town's *Spatial Development Framework* (CTSDF, 2012), which illustrates the population density of the various suburbs within the Cape Town area and is shown in **Figure 1.2**.

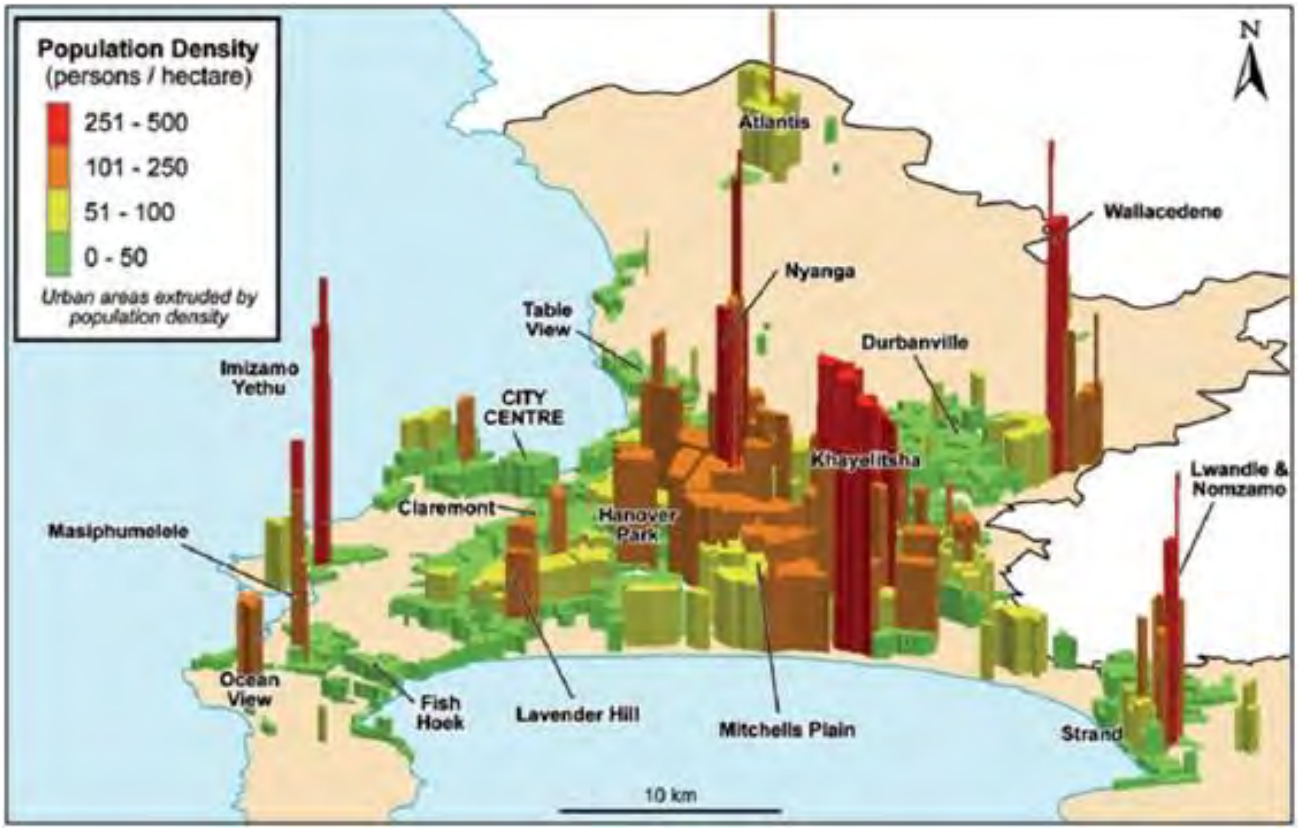

Figure 1.2: Cape Town Population Density Source: CTSDF

Figure 1.2 shows that, while there is a low population density immediately surrounding the CBD, areas of high density are located further east of the CBD.

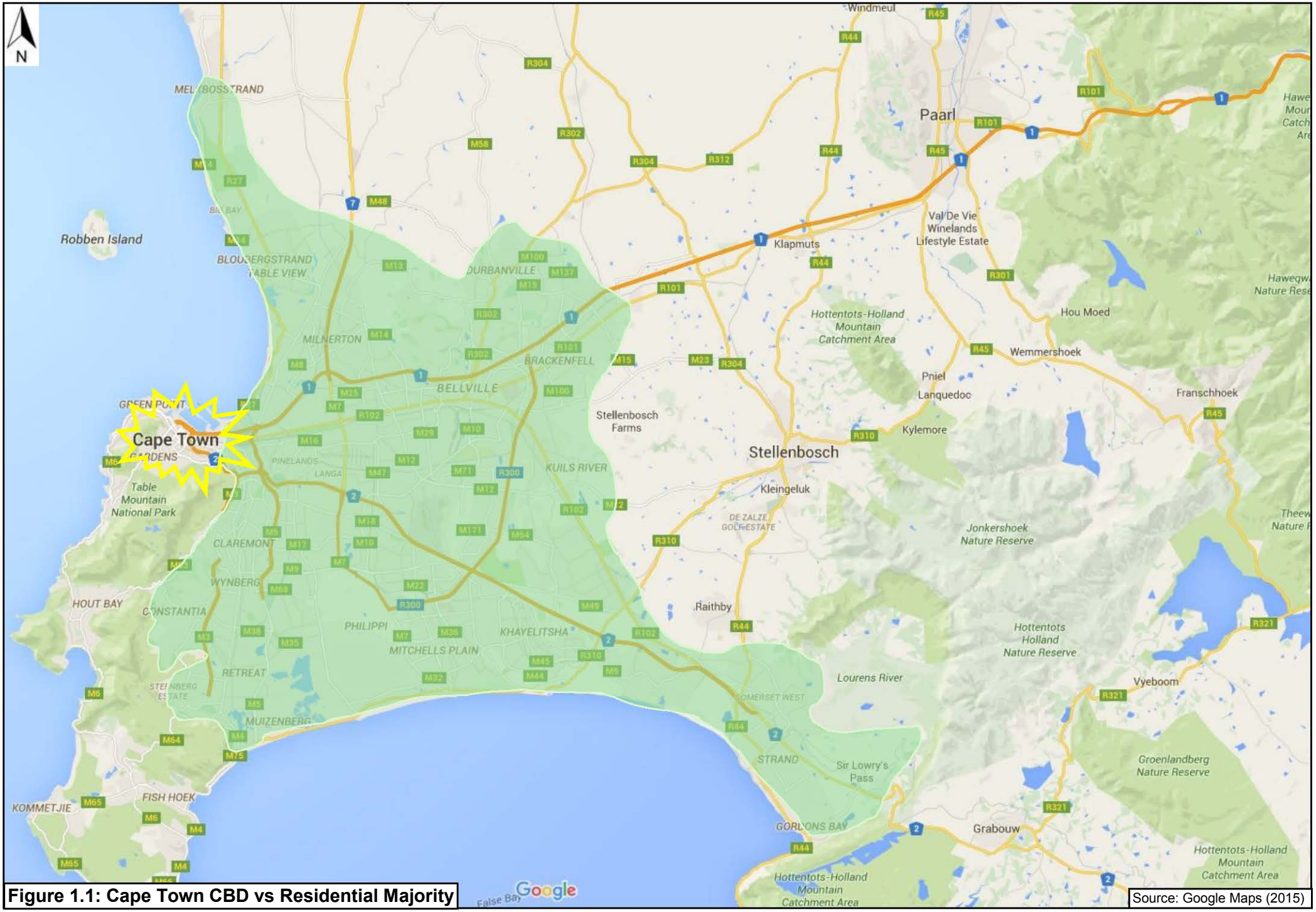

Figure 1.1: Cape Town CBD vs Residential Majority

Source: Google Maps (2015)

1.2.1 Existing Road Network

As such, there are a limited number of road-based routes to access and exit the City's Central CBD, to and from these east-lying areas. These routes are shown in **Figure 1.3** and described in terms of Transport for Cape Town's Public *Right of Way*: *Road Network* Map (August 2013):

- The **N1** is a four lane dual carriageway in the vicinity of the CBD and becomes a three lane dual carriageway in the vicinity of the N1 / R27 interchange. This road is classified as Class 1 Freeway and has a speed limit of 80 km/hr (approaching the CBD).
- **De Waal Drive** is a two-lane dual carriageway and is classified as Class 2 Expressway and has a speed limit of 80 km/hr.
- **Nelson Mandela Boulevard** is a three-lane dual carriageway and is classified as Class 1 Freeway and has a speed limit of 80 km/hr.
- **M4 (Victoria Road)** is a four lane divided road and is classified as Class 3 Secondary Arterial and has a speed limit of 60 km/hr.
- **R102 (Albert Road)** is a two lane undivided road and is classified as Class 3 Secondary Arterial and has a speed limit of 60 km/hr.
- **Keizersgracht Road** is a four lane divided road and is classified as a Class 5 Access Road and has a speed limit of 60 km/hr.

In addition, various physical "pinch-points" located along these major roads (as a result of lane merges) act as a volume constraint; meaning only a certain amount of vehicles is allowed in or out of the CBD during the peak periods. These pinch points, therefore, have adverse effects during the peak periods:

- During the **AM peak period**, there is significant congestion for traffic travelling inbound (towards the CBD), with low levels of congestion experienced within the CBD.
- During the **PM peak period**, there is significant congestion for traffic travelling outbound (away from the CBD), with relatively low levels of congestion within the CBD, although there is significant congestion in the immediate vicinity of these access routes.

Motorists, therefore, attempt to bypass sections of congestion along these six major access routes by rat-running (through Walmer Estate, Upper Woodstock and other areas), before re-entering further downstream (i.e. "ahead" of the congestion). This practice not only has an effect on the community residing in the suburb, through which they are rat-running, but upon re-entering these major access routes, cause significant delay to vehicles downstream of these accesses.

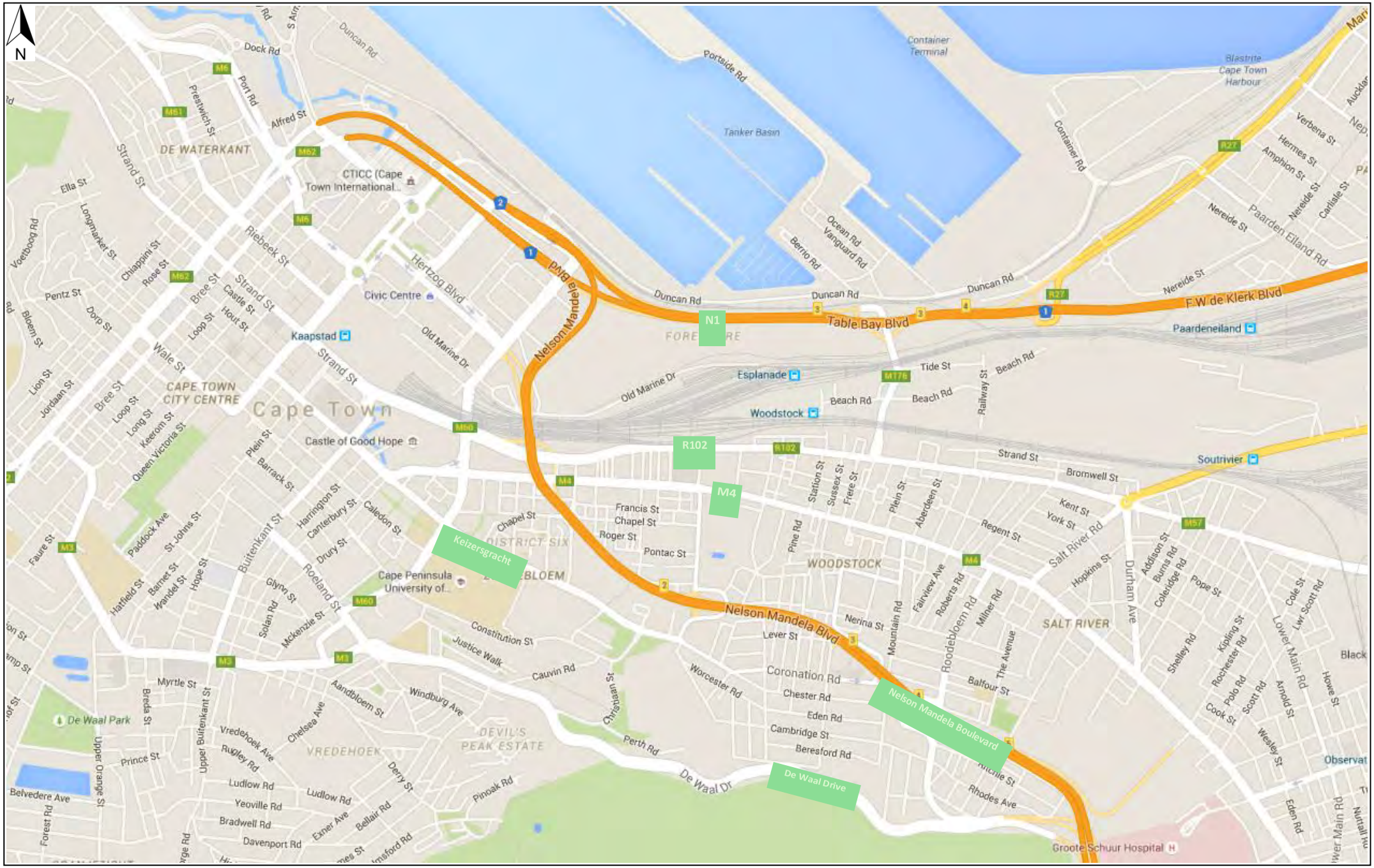

Figure 1.3: Roads Linking the CBD to Eastern Areas of the City

Source: Google Maps

It is important to note that of these 6 major access routes, only one road, Keizersgracht feeds directly into a suburban area, Walmer Estate (i.e. the study area) and the road network within this area is designed in such a way that direct connections to either Nelson Mandela Boulevard or De Waal Drive are available further east.

1.2.2 Suburbs Located Adjacent to the Cape Town CBD

There are a number of residential suburbs located within close proximity to certain major access routes to the east of the CBD. The suburbs of Walmer Estate, University Estate and Upper Woodstock (and District Six) are located adjacent to Nelson Mandela Boulevard (M3), De Waal Drive and Victoria Road (M4) as shown in **Figure 1.4**. As mentioned previously, since the majority of the CBD-bound trips originate from east of the CBD, an excessive number of vehicles make use of these suburbs to perform rat-runs during the PM peak period, in an attempt to bypass congestion experienced on the major routes.

The increase in vehicle volumes within these suburbs as a result of the rat-runners has a significant effect on the health and safety of residents, thereby comprising their quality of life. In addition, this unwanted thoroughfare also carries an economic impact for the residents by decreasing property values within the immediate vicinity.

1.3 Objectives

The main objective of this study is to (pragmatically) assess a selection of potential rat-run mitigating measures that could be implemented within a study area, in order to identify a preferred alternative. Recommendations regarding the way forward will also be presented. The following questions are investigated as part of this study, either in a general sense, or specific to the study area:

- Why do motorists rat-run?
- What decisions are made prior to a driver selecting a route?
- What effect does land use planning have on travel behaviour, with specific reference to rat-running?
- Can rat-running be mitigated, and if so, what types of measures are typically used to deter this?
- What is the City's medium-to-long term planning approach and how will this affect travel behaviour?
- Are there any future plans for the redevelopment of District Six and if there are, how will this affect the current traffic situation (in relation to the study area)?
- What are the main rat-running routes through the study area and how many vehicles make use of these routes during the weekday PM peak period?
- What mitigating measures can be implemented within the study area to successfully mitigate the rat-running volumes and how will the efficacy of these measures be quantified?
- What is recommended for the study area going forward?

The research intends to explore the reasons behind rat-running and to investigate the effectiveness of mitigating measures currently used to discourage rat-runners, both locally and internationally. Furthermore, the study will attempt to quantify the number of motorists currently rat-running through a pre-defined study area and, using this data, assess the efficacy of selected mitigating measures for implementation within the area. The study will conclude with a way forward, defining short, medium and long term strategies (or recommendations) to reduce the number of rat-runners moving through this area, with a focus on recommending further investigation of the preferred alternative by way of traffic simulation modelling.

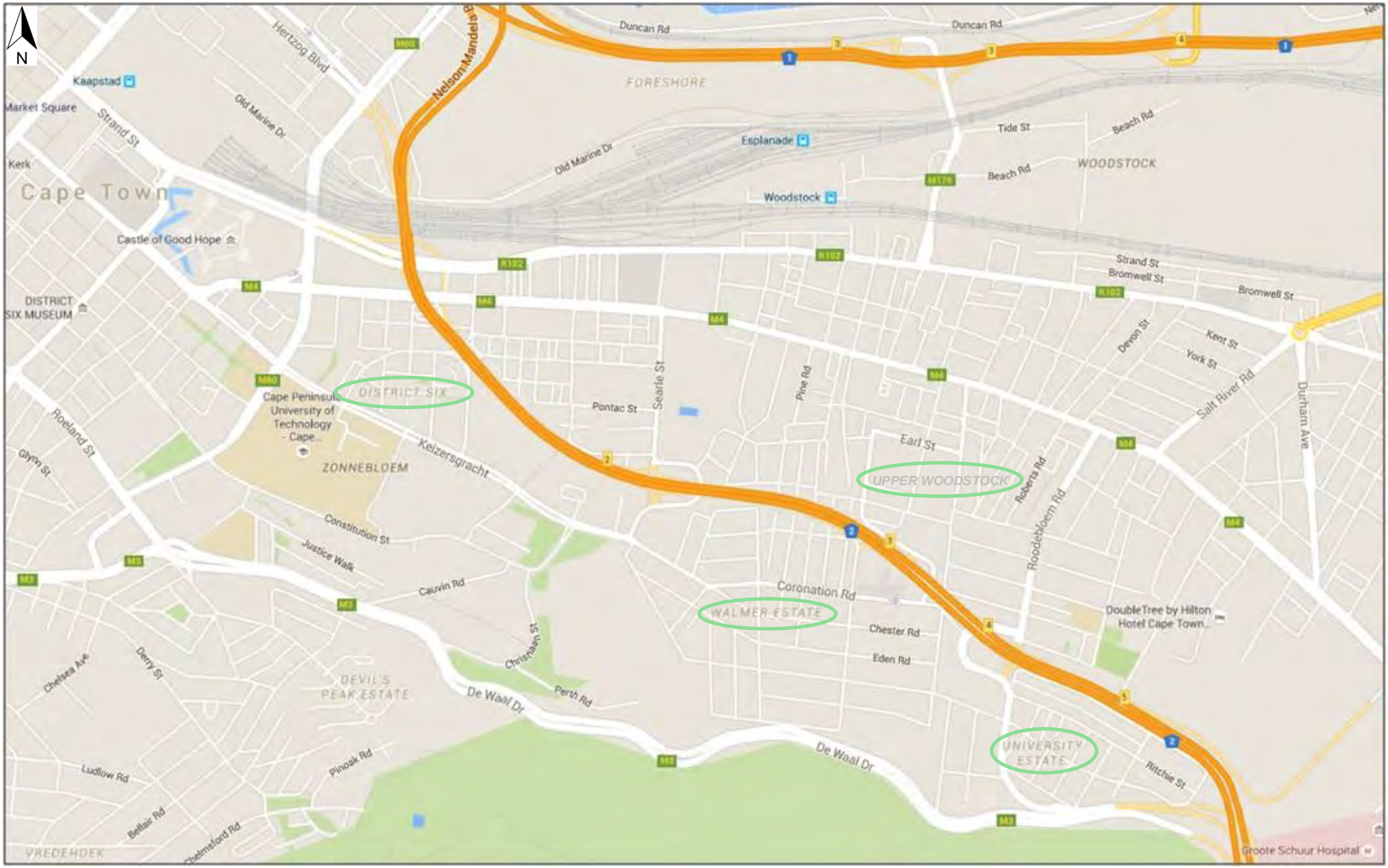

Figure 1.4: Suburbs Located Directly East of the CBD

Source: Google Maps

1.4 Methodology

The proposed methodology for this study necessitated the identification of the following key issues and processes:

Project Start

The minor dissertation research proposal was drafted and submitted for approval. Once approval was granted, data collection and analysis could begin.

Literature Review

A literature review was carried out on the following:

- Rat-running and route choice
- Land use planning / management and the impacts on traveller behaviour
- Short-term solutions for reducing rat-running volumes
- Unclassed matters for review

Data Collection

A number of vehicle number plate recognition surveys and an intersection survey at various locations relevant to the study area were undertaken during the weekday PM peak period. This was done in an attempt to identify the main rat-run routes and to quantify the number of rat-runners moving through the study area during this period.

Analysis of Data and Assessment

Data obtained from the surveys was captured into an electronic spreadsheet. The vehicle number plate recognition survey data was interrogated to determine the peak and overall rat-run volumes per route during the survey period. This provided on-the-ground information that would be used to develop proposed mitigating measures.

Developing Proposed Mitigating Measures and Alternatives

Data obtained from the surveys and information presented in the literature review section was used to identify different mitigating measure options that would likely reduce the number of rat-runners currently travelling through the study area. A high-level assessment of these proposed measures was undertaken and a multi-criteria analysis was used to determine the preferred alternative. Recommendations regarding the implementation of the preferred alternative solution and the way forward are provided.

1.5 Scope and Limitations

The scope of this study is defined as:

- Identify the study area investigated.
- Undertake a review of available literature to better understand rat-running and investigate various rat-running mitigating measures as well as the efficacy of these measures.
- Initiate vehicle counts to quantify the amount of vehicles currently performing rat-runs through the study area during the weekday PM peak period.
- Use the count data to determine the most popular rat-run routes through the study area.
- In conjunction with the survey data, the information discussed in the literature review section will be used to indentify three alternative mitigating measures as a solution to the study area's rat-run problem.
- A multi-criteria assessment of the three alternative mitigating measures will be performed to determine the preferred solution, with recommendations on the way forward, provided.

The limitations of this study are:

- This study will only investigate the occurrence of rat running during the PM peak period (16:00 – 18:00), as besides this time period, the study area is otherwise unaffected by rat-runners.
- Not all of the rat-runs routes located within the study area were surveyed.
- Due to financial considerations, surveys were only undertaken on one day during the PM peak period to quantify the number of rat-runners.
- A pragmatic (high-level) approach to the assessment of the effectiveness of the proposed mitigating measures will be undertaken and as such the assessment is heavily weighted in favour of the information presented in the literature review
- No traffic simulation modelling will be undertaken to evaluate the effectiveness of the proposed mitigating measures due to time and financial constraints
- Traffic implications resulting from changes to the petrol price have not been included
- No detailed designs of the proposed mitigating measures have been prepared
- Additional studies (eg in the form of traffic simulation modelling) may be required to accurately test the efficacy of these measures, and their effect on the surrounding road network

1.6 Content of the report

This report contains a literature review chapter, **Chapter 2**, which seeks to define rat-running and investigates why people make certain route choice decisions. The role that land use planning has on traveller behaviour is then explored, providing an overview of certain planning and land use configurations and their associated implications. This information is then contextualised by examining the City of Cape Town's long-term planning approach and the possible impacts this may have, before focussing on future proposals for the study area and adjacent suburbs.

Different types of mitigating measures are then presented followed by a summary regarding the efficacy of each. To conclude this chapter, a brief discussion regarding other factors that were identified (pertaining to Cape Town, the study area and in general) as potentially having an impact on rat-running is presented and discussed. This information will comprise the majority of criteria used in the multi-criteria analysis of the proposed mitigating measure alternatives.

Chapter 3 sets out to clearly define the study area and describes the survey methodology used to collect the data. The main rat-running routes forming the focus of this study are also identified. The results of the surveys are then presented in an attempt to quantify the number of rat-runners travelling through the site, with an interpretation of these results also provided.

Chapter 4 uses information presented in **Chapters 2** and **3** as a basis to identify and exclude certain mitigating measures from consideration due to perceived inefficacy. This process makes it possible to select better examples of various short, medium and long term measures that upon implementation may solve the study area's rat-running problem. A brief overview of each of these measures is provided, which includes a discussion / assessment regarding each measure's potential advantages, disadvantages and general efficacy. This chapter concludes with multi-criteria analysis of the different alternatives, which serves to reveal the preferred alternative.

This report concludes with **Chapter 5**, which provides a summary of the key findings of the literature review and surveys. It also documents the way forward, and recommendations are made for further assessment regarding the efficacy of the proposed mitigating measures by way of analysis (i.e. dynamic traffic simulation model).

2 LITERATURE REVIEW

2.1 Introduction to the Literature Review

In order to adequately satisfy the objectives of this study, extensive interrogation of the available literature is required. For the sake of brevity, specific topics were chosen for review, identified as important to the objectives. The investigation of these topics is presented in a specific order, allowing the knowledge gleaned from the revision of this information to form a logical progression.

It is, therefore, important to begin by contextualising the existing traffic situation within Cape Town as this provides insight into modal splits, congestion levels, etc and acts as a broader background to the rat-running problem in Cape Town. Following on from this, a deeper insight is required into why drivers choose certain routes (over others) with the purpose of identifying how a change in route choice can be precipitated.

In addition, cognisance must be taken of what role, if any, the arrangement of land uses has on travel behaviour with further investigation into the Cape Town context required in this regard. This process allows for an assessment of the City's proposed medium-to-long term planning strategies in relation to expected traveller behaviour, making it possible to conclude on the impact that these strategies will have (particularly) on rat-running. Once this has been established, the types, efficacy and suitability of various rat-run mitigating measures will be researched with a view to possible implementation within the study area. This chapter concludes with a section of unclassed matters for discussion, issues that don't particularly fit into the above mentioned topics, but are considered as potentially playing an important role in traveller behaviour / the overall outcome of the study. In this section issues such as law enforcement, public transport, etc will be further explored. Once compiled, it is expected that information obtained from this review will be sufficient in assisting with adequately satisfying the study objectives.

2.2 Introduction to Rat-running

Traffic congestion has become a part of life for many people living in urban areas across the world. Studies show that in South Africa, vehicle ownership (per household) has increased by 5.6%, from 22.9% in 2003 to 28.5% in 2013 (*StatsSA,* 2014*)*. As a comparison, vehicle ownership for the other BRICS nations is: 24.9% for Brazil, 31.7% for Russia, 1.8% for India and 11.3% for China (*World Bank*, 2015); although it could be argued that the high population of China and India distorts their results somewhat. Furthermore, in South Africa, 30.8% of workers relied on private transport to undertake work-related trips, compared to only 26.5% making use of public transport (*StatsSA,* 2014*)*.

In Cape Town, the private vehicle/public transport modal split for workers entering the CBD was reported as 63:37 in favour of private transport (*City of Cape Town*, 2013), which shows that private vehicles usage is still almost twice as popular for CBD-bound workers. With increased levels of car ownership and workers favouring the use of private vehicles over other transport modes, the obvious solution would seem to be for the Western Cape Government/City of Cape Town to commission the widening of certain major roads to alleviate congestion. It has been argued however, that this does not have the desired effect.

In the United Kingdom, the certainty of congestion in some urban road networks has been officially recognised since their Department for Transport set down policies based on the report *Traffic in Towns* (1963):

> "*Even when everything that it is possibly to do by way of building new roads and expanding public transport has been done, there would still be, in the absence of deliberate limitation, more cars trying to move into, or within our cities than could possibly be accommodated*".

Furthermore, a 2011 study in the *The American Economic Review* indicates that there may be a "fundamental law of road congestion." The researchers, from the University of Toronto and the London School of Economics, analysed data from the *U.S. Highway Performance and Monitoring System* for 1983, 1993 and 2003, in addition to information on population, employment, geography, transit, and political factors. The results of this study showed that the number of vehicle-kilometres travelled (VKT) increases in direct proportion to the available lane-kilometres of roadways. This implies that widening existing roads or building new roads only results in additional traffic to be added to the upgraded network. The number of vehicles then continues to rise until such time as the peak congestion returns to the previous (before upgrades) level (*Duranton and Turner, 2011*). As such, the

strain of increasing levels of vehicles ownership and additional vehicles being added to already-congested road networks forces drivers to find alternative solutions to the congestion problem, in an attempt to decrease travel times. One of these alternatives is rat-running.

2.3 Existing Traffic Situation in Cape Town

It is important to quantify the existing traffic scenario within Cape Town and in particular, the CBD, as this provides initial insight regarding the reasons for the current rat-running problem. A large number of vehicles on the road network (i.e. high traffic volumes) and high levels of congestion will support the "fundamental law of road congestion" and explain why motorists are currently rat-running in various areas across the City.

The City of Cape Town undertook a screenline survey in 2012 that involved counting the total number of motorists, public transport commuters (all modes) and non-motorised transport users (an insignificant number) entering and exiting the periphery of the CBD (on all possible routes) during the AM (06:00 to 09:00), interpeak (09:00 to 16:00) and PM (16:00 to 19:00) peak periods. The results of these surveys are summarised in **Table 2.1**.

Table 2.1: Cape Town CBD Screenline Count Results Data

Mode	Morning Peak (06:00 to 09:00)				Interpeak (09:00 to 16:00)				Evening Peak (16:00 to 19:00)			
	Vehicles		Commuters		Vehicles		Commuters		Vehicles		Commuters	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
INBOUND - Towards the CBD												
Private Transport	59 472	95	87 593	50	77 256	95	113 273	67	24 068	92	35 835	59
Public Transport	3 365	5	86 142	50	3 762	5	55 890	33	2 005	8	24 808	41
Total	62 837	---	173 735	---	81 018	---	169 163	---	26 073	---	60 643	---
OUTBOUND - Away from the CBD												
Private Transport	27 071	90	36 595	56	71 532	95	105 411	68	30 151	92	45 935	40
Public Transport	2 848	10	28 720	44	3 737	5	49 157	32	2 726	8	69 007	60
Total	29 919	---	65 315	---	75 269	---	154 568	---	32 877	---	114 942	---

Source: City of Cape Town (2012)

The above table shows that, while the overall commuter numbers are comparable within the peak periods (within 20%); significantly more private vehicles are required to transport commuters during these periods. It is, therefore, inferred that the limited space available within the existing Cape Town transport network is dominated by private vehicles and subsequently, it can be anticipated that a significant amount of congestion is present on the roads during this time.

Indeed, results from a study undertaken by GPS manufacturer Tomtom (2014) show that the Cape Town road network is the most congested in the country, when compared to six other cities. The study calculates congestion level percentages, which is equivalent to the increase in travel time in comparison to free flow speed. The congestion percentages of the six South African cities are summarised in **Table 2.2**.

Table: 2.2: Tomtom Congestion Levels

City	Overall Congestion	Morning Peak	Evening Peak	Highways (Freeways and Expressways)	Non-highways (all other roads)
Cape Town	27%	71%	58%	20%	30%
Johannesburg	25%	60%	55%	15%	30%
East London	22%	47%	47%	11%	25%
Pretoria	22%	50%	43%	9%	27%
Durban	18%	42%	40%	11%	26%
Bloemfontein	12%	24%	22%	7%	16%

Source: Tomtom (2014)

Table 2.2 shows that when compared to the other South African cities, Cape Town experiences particularly high levels of congestion during the morning peak, in fact, Cape Town exhibits the highest level of congestion for every scenario compared in the table.

This information confirms that Cape Town has a significant congestion problem throughout the course of a normal weekday and it is possible to conclude this to be the root of the current rat-running problem.

2.4 Route Choice and Rat-running

2.4.1 Route Choice

It is important to realise that, while motor vehicles perform the trips undertaken every day on our transport networks, the driver (a human being) is actually in control of the decisions related to the choice of route taken for a particular trip. As such, from a psychological standpoint, there are two main theories explaining how behavioural choices are made and these are described briefly in the following sections.

Rational Choice Theory

The conventional approach to travel choice theory is based on the assumption that people (i.e. drivers) are "rational actors". This assumption implies that they will attempt to maximise the attainment of a set of goals and that they are fully informed of all the alternatives and have comprehensive information (*Behrens*, 2012). Conversely, non-rational behaviour implies not selecting the best option out of a range of alternatives. This type of behaviour may result from: unreasoning commitment to a given course of action, education, training, experience that prevents realisation of the greater scenario or some form of incompetence (*Behrens*, 2012). Three models that use rational choice theory as a basis are summarised as:

- **Utility maximising behaviour** states that the decision maker ranks the available alternatives (from least preferred to most preferred) on the basis of their relative attractiveness (utility) and will always attempt to gain maximum utility or benefit in choosing an alternative (*Behrens*, 2012). An extension of this, **random utility theory**, acknowledges that decision makers do not always (if ever) have perfect information on the relative utility of alternatives and assumes that a decision maker will still select that alternative that appears to maximise benefits, but this is subject to individual variation in perceptions (*Behrens*, 2012).
- The **Deficit model** is where a linear succession is assumed; from the formation of environmental knowledge → formation of pro-environmental attitudes → pro-environmental behaviour. It is important to note that the failure to turn pro-environmental attitudes into pro-environmental behaviour is assumed to be the result of insufficient information; related to both understanding the impact an individual's travel behaviour has on the environment and of the range of travel alternatives to materialise pro-environmental behaviours. Subsequently, the assumption is that "...*those with existing pro-environmental attitudes, but a deficit of information as to the impact of their*

behaviour and behavioural change strategies, would then choose to modify their behaviour on a rational basis" (*Behrens*, 2012).

- **Satisficing behaviour** permits a decision based on results that are 'good enough' and is, therefore, not necessarily considered as the "maximum" (*Behrens*, 2012). This behaviour acknowledges that these individuals are not totally informed, cannot consider all the alternatives, and stop searching when an alternative is deemed "good enough" (i.e. they are satisfied). The above implies that the individual has a preconceived outcome in mind and any alternative that satisfies this outcome will be selected, regardless of whether it is the alternative providing maximum benefit.

Prospect Theory

This theory maintains that the context within which a choice is made, and the way in which choices are presented will influence the decision-making process (*Behrens*, 2012). Individuals make decisions based on the potential value of losses and gains of the proposed alternatives, rather than the final outcome and will, therefore, choose the alternative that minimises potential losses (i.e. loss aversion).

Discussion

If it is assumed that rat-runs represent the quickest route between two points, and that a potential decrease in travel time (compared to travelling on congested main routes) is perceived as the most important factor for motorists, then it can be argued that most of the motorists who rat-run do so as a result of utility maximising behaviour, i.e. they are aware of the congestion problems experienced on the transport network and, therefore, select the rat-run route as it gives them the lowest travel time or the gain in reduced travel time outweighs any potential losses in the form of fines, etc. Assuming motorists remain loyal to this theory, it is necessary to significantly increase the travel time on the rat-run to facilitate a switch to a more appropriate route, or to impose the threat of significant penalty to facilitate the switch. It should be noted, however, that if it were possible to change the way people are making these route choices, then other options exist:

- Were they to follow the deficit model, then the impact of the choice on the environment would result in a route change (although perhaps they would first need to be made aware of these impacts).
- If the motorists follow satisficing behaviour and the travel time on the rat-run is sufficiently affected, they would consider switching over to a more conventional route as it would be "good enough".

Conceivably, the best approach to deter rat-runners based on route choice theory would, therefore, be to develop an all-encompassing strategy that addresses all of the above options.

2.4.2 Effecting a Change in Route Choice

There are two main theories that attempt to explain when behavioural change occurs (i.e. at what point does a motorist decide to make a change in route selection?). These three theories are:

Habit Formation Theory

A growing body of literature states that individuals do not re-evaluate all aspects of their travel decisions on a daily basis as inferred in the behavioural choices behind route selection (**Chapter 2.1.1**) and the conventional four-step model assumes (i.e. trip generation, trip distribution, mode choice and route assignment). George Kinglsey Zipf (1949) argued that a unifying principle, the principle of least effort, underlies essentially the entire human condition. This principle states that people (in this case motorists) will act so as to minimise their probable average rate of work (e.g. shortest travel time) and should an outcome be possible through more than one approach, most people will select the option that requires the least effort (*Behrens*, 2012). It has been argued that this principle offers a more plausible explanation of habitual travel behaviour as opposed to the maximising frameworks discussed previously. As maximisation significant effort in obtaining information and using this to calculate relative costs and benefits, the least effort principle merely involves drawing from memory which selections have worked in the past and then repeating these choices, rather than considering the alternatives (i.e. “the tried and test method”). It should be noted that the only way that behavioural patterns are changed is if a certain “trigger” is introduced e.g. changing jobs, moving house, car crash, etc.

Cognitive Dissonance Theory

This theory (*Festinger*, 1957) is centred on the role of the individual’s concept of self as a motivator of behaviour. When the individual’s behaviour conflicts with the attitudes and values they hold about themselves, they may experience discomfort which will motivate them to change; to re-align their behaviour with said attitudes and values (*Behrens*, 2012).

Discussion

To facilitate the changes discussed in the previous chapter two possible solutions exist. For those motorists following habit forming theory, a trigger in the form of a penalty (i.e. traffic fine) or making the rat-run route sufficiently onerous (increase in effort) may cause the motorist to re-evaluate their travel decision and precipitate a change to a more appropriate

route. Those motorists following cognitive dissonance theory could be motivated to change from the rat-running route through awareness campaigns showing the impact that there decision makes on the affected community. This may resonate with the individual as it can be assumed that this would generally be in contradiction to their values, bringing about a change in route.

2.4.3 Response to Behaviour-change Interventions

There are a number of theories regarding how individuals (i.e. the decision maker) respond to possible behaviour changing interventions.

Self-perception Theory

This theory, offered by Bem (1972), proposes that people assume attitudes by observing their own behaviour (*Behrens*, 2012). This means that people will attempt to change their behaviour without changing their beliefs and attitudes, which can ultimately result in their beliefs and attitudes adopting this new behaviour. Furthermore, if a gap exists between attitude and behaviour an adjustment will be made to either attitude or behaviour; thus behaviour can be influenced by encouraging people to try a new behaviour, which in turn brings about a positive change to their attitude regarding the new behaviour, although this is only likely when the outcome of their new behaviour is positive (*Behrens*, 2012).

Goal Setting Theory

This theory, offered by Latham and Locke (1991), states that human behaviour is motivated by conscious purpose; the action initiated is as a result of a stipulation of what is important to the individual. Goals are then set to achieve this action and a plan is then derived to achieve these goals (*Behrens*, 2012). It should be noted that the more specific and difficult a goal is, the higher the level of effort and performance will be towards reaching the goal. In this theory, the way people respond to changing circumstances would depend on if a discrepancy is detected between their goals and their present experience. If a discrepancy is detected, people will follow a cost minimising approach, i.e. adaptations in travel behaviour are determined on which “costs” less to implement. If the initial choice turns out to be ineffective after an initial trial period, the individual will move on to a more “costly” alternative.

Discussion

The above provides evidence that it is possible to change an individual’s behaviour, without first changing their beliefs and attitudes. If this can successfully be achieved, then their beliefs and attitudes will adopt this new behaviour. In terms of goal setting theory, however, it is important to undertake a pro-active approach (whichever rat-run curbing strategy is

selected) to prevent those motorists who have switched over to the more conventional routes from switching back to rat-runs.

2.4.4 Route Assignment Techniques

There are a number of methods that are used by transport engineers to estimate the different routes drivers will use to travel between a set origin and destination. Although these techniques might not be entirely accurate, they provide a reasonable approximation of the expected outcomes. When undertaking these estimations, a number of factors are considered as affecting the route choice, and these are inter alia: level of service, travel time, costs, comfort, etc.

One such method is equilibrium assignment, derived from Wardrop equilibrium conditions. Wardrop stated two principles of equilibrium (*Wardrop & Whitehead*, 1952):

> *"The journey times in all routes actually used are equal and less than those which would be experienced by a single vehicle on any unused route."*
>
> and,
>
> *"At equilibrium the average journey time is minimum."*

The core of these principles revolves around the theory is that motorists will strive to find the shortest (i.e. most attractive) route between origin and destination. Network equilibrium, therefore, occurs when no motorist can decrease travel effort by shifting to a new route. This occurrence is classified "user optimal conditions", as no user will gain from changing travel routes once the system is in equilibrium.

These assumptions seem realistic for the present traffic situation in Cape Town and this could explain why certain motorists make use of rat-runs; alternative routes (main routes) are congested and the indirect routes through residential areas consequently become more attractive, as they represent a potential decrease in travel time to the motorist. This infers that in order to eliminate a rat-run completely, it is necessary to close off the accesses being used to connect to the external road network, which is not always possible or practical. With the above in mind, the goal should, therefore, be to reduce the number of rat-runners to a "manageable" / "acceptable" number.

2.5 Land Use Planning, Management and Travel Behaviour

Land use planning can be defined as “having the goal of ordering and regulating land use in an efficient and ethical way with a focus on the future”. The regulation of land use is, therefore, important and is controlled through zoning, which controls the type and extent of activities that can be accommodated on a given piece of land, and the ways that the buildings may be situated or shaped. This infers that land use planning has a significant effect on the transport network and travel patterns and the type of planning configurations equally so.

The introduction of formalised (planned) local area movement network configuration and management practices were developed as a response to various changes that were occurring in the local environment at the time. According to Behrens (2002a) the emergence of local movement network configuration and management ideas can be broken into five overlapping periods as shown below in **Table 2.1**.

Table 2.1: Movement Network Design Through The Years

Trigger	1900's	10's	20's	30's	40's	50's	60's	70's	80's	90's	2000's
Responses to industrialisation and housing conditions											
Responses to technological change and traffic problems											
Responses to traffic conflicts and decaying street life											
Responses to poverty and housing costs											
Responses to car dependency and pollution											

Source: Behrens 2002(a)

The above table shows that certain triggers precipitated a change to the “status quo” local network configurations at the time, with planners attempting to change their planning in an attempt to address the prevailing issues in a proactive manner (sometimes attempting to address the source). Where in the past, planners were concerned about housing conditions; they are now faced with problems related to car dependency, pollution and congestion problems. It could be argued that the current situation could be viewed as a direct result of earlier planning principles. It should be noted, however, that Banister (2012) states that income and fuel prices are normally considered to be much stronger influences on travel patterns than urban form and that planning decisions are seen as costly and

difficult ways to influence travel behaviour. He goes on to speculate that market pressures for decentralisation are likely to be stronger influences.

Certain land use configurations and the consequences of improper or poorly regulated planning are discussed, in relation to the effect they have on the transport network (and the minor dissertation topic) below.

2.5.1 Urban Sprawl

Urban sprawl describes the expansion of human populations away from central urban areas into low-density mono-functional communities that are usually car-dependent. While there are differing definitions for the term, researchers concur that the term involves unplanned, incremental urban growth which is often regarded unsustainable as a result of inefficient resource utilisation. It should be noted that urban growth may not lead to sprawl, but sprawl induces growth in urban areas (Bhatta, 2010) The topic of urban sprawl has become somewhat of a contentious issue among academics, more specifically "*between those advocating a planning approach and those advocating the efficiency of the market*" (Chin, 2002). As such, consequences of urban sprawl may have both positive and negative impacts; however, negative impacts are generally more highlighted because this growth is often uncontrolled or uncoordinated and the negative impacts therefore appear more significant (Bhatta, 2010).

It should be noted that, as a result of previous legacy policies, the majority of South Africa's towns and cities are characterised by urban sprawl. Although the causes behind this sprawl may differ from a typical example (e.g. forced relocation as opposed to urban growth), the consequences resulting from sprawl are considered to (generally) be the same.

A general overview of the positive and negative consequences of sprawl is provided in the section below.

Negative Consequences of Urban Sprawl

The consequences of urban sprawl are far reaching: sprawl leads to increased driving and, therefore, increased vehicle emissions (contribution to air pollution), both of which have a negative impact on human health. It should be noted that this is contradictory to what happened in the years following World War II (as a result of the increase in vehicle ownership) when public health officials recommended the health benefits of suburbs due to pollution from soot and industrial fumes in the city centre.

This increase in automobile dependency also implies reduced physical activity and further negative health consequences. The *American Journal of Public Health* and the *American*

Journal of Health Promotion have both stated that there is a significant connection between sprawl, obesity, and hypertension (McKee, 2003). It is also logical to deduce that an increase in the vehicle kilometres travelled by a motorist (i.e. increased exposure to driving) as a result of urban sprawl increases the probability of automobile crashes and pedestrian injuries, as investigated by De Ridder (2008). Furthermore, living in larger, spread out spaces, generally, makes public services more expensive e.g. the provision of public transport services, highway infrastructure, potable water, sewers, etc. In addition, residents of low-density areas spend a higher proportion of their income on transportation than residents of low density areas (McCann, 2000).

The increased reliance on private vehicles as a result of this sprawl presents a challenge for city planners to accommodate for the increased parking demand within a CBD. A study by Cutter et al. (2010) on the effect of minimum parking requirements in Los Angeles concluded that the results provide evidence to suggest that although parking availability has a positive impact on property values, this impact is smaller than the potential alternative uses for this space and this onerous requirement for developers to provide parking tends to reduce the value of their development (MRCagney (Pty) Ltd, 2013). From this, it can be inferred that sprawl has an economic impact on cities in terms of parking provision, as the land used to provide parking can be better used. Another economic consequence of sprawl is the "killing off" of CBD commerce by attracting consumers to larger regional malls and restaurants (Pedersen et al., 1999).

Crane (2008) explains that the costs of urban sprawl are nuanced and that urban sprawl leads to the undervaluation of open space, excess congestion and underpriced environmental costs. Although higher density development results in shorter trips but increased congestion, Newman and Kentworthy *(1989*) find that the former effect overwhelms the latter; even though vehicles are not as fuel-efficient in dense areas owing to traffic congestion, fuel consumption per capita is still substantially less in dense areas because people drive so much less. In areas such as Cape Town, it can further be argued that since there are many outlying areas, the excessive congestion during peak periods leads to increased travel times and as a result, rat-running.

Furthermore (and perhaps more importantly), Crane (2008) explains that urban sprawl can precede regulatory failure in so much that it leads to/forces decentralised land use authorities and segmented planning, creating inefficiency. This inefficiency can be highlighted by the City of Cape Town's decision to replace the 27 separate zoning schemes with the integrated *Cape Town Zoning Scheme* in 2012 (which has since been replaced by the Western Cape Government's *City of Cape Town Development Management Scheme Bylaw,* 2015).

Positive Effects of Urban Sprawl

Bruegmann (2008) argues that urban sprawl is a natural occurrence and can be traced back to ancient Rome, since living in the city (i.e. the CBD) is, typically, associated with congestion, unsanitary living conditions and poverty, as soon as people can afford to they move further out of the city. Furthermore, he speculates the increase in private vehicle usage (experience in most of the world) is as a result of private vehicle trips being faster than public transport and it offers motorists increased mobility and to summarise, people have started valuing their time more.

Bhatta (2010) explains that the positive implications of urban sprawl include: higher economic production, opportunities for the underemployed and unemployed and, therefore, a better life, and better lifestyles. Since land is readily available in these outlying areas, the associated cost of housing in these areas is less expensive in comparison to the CBD, allowing families the opportunity of owning a larger home on larger plots. Urban growth (which may lead to urban sprawl) can also extend better basic services, such as transportation, sewer, and water, etc as well as other specialist services such as better educational facilities, health care facilities, etc. to more people. Furthermore, as long as developers are responsible for the full costs of neighbourhood infrastructure, and pass such costs on to homebuyers and other end-users of land, lower-density development patterns with satisfy the economic efficiency (at least with respect to infrastructure costs).

Discussion

As mentioned, Cape Town presents a unique scenario in that Apartheid gave rise to high density informal (residential) settlements located on the periphery of cities. The information above reveals that while the positive aspects of urban sprawl may lead to positive impacts on individuals e.g. bigger house (not always the case in South Africa), cheaper land etc, the negative impacts of urban sprawl are far-reaching and affect not only those forming part of the sprawl, but on the greater population through e.g. city-wide congestion instead of localised congestion, planning inefficiencies, etc.

This city-wide congestion, in conjunction with increased travelling distances, also infers longer travel times and as such, motorists attempting to shorten their travel times through various means (e.g. rat-running). Since the root cause of this practice stems from a city-wide land use and planning problem, one cannot expect significant and sustainable change in individual driver behaviour without a complimentary change in the City's land use and planning policy. The implementation of such a policy is, therefore, of the utmost importance to assist in improving traffic conditions and reducing road network congestion thereby addressing the current rat-running problems.

2.5.2 Transit-oriented Development

There are numerous different land use configurations that can be used (and have in the past been used) in land use planning, such as: traditional neighbourhood developments, transit oriented developments (TOD's), etc. with configuration devised so as to address specific triggers/problems. Due to the considerable amount of coordination, planning and time required to ensure that a chosen policy is a success, it is logical to infer that a city's current land use policy is likely to remain in place for the long term future.

For this reason, only the TOD planning approach will be investigated in the study, as the City of Cape Town has indicated through an official media release that TOD has been chosen as one of the key components for Cape Town to be the most efficient city in Africa by the year 2032 (City of Cape Town, 2014). The focus of the City of Cape Town's decision to implement TOD is, therefore, "*to undo apartheid-era spatial planning and to mitigate the effects of increasing urbanisation"* i.e. sprawl (City of Cape Town, 2014).

Overview of TOD principles

A TOD is a mixed land use development comprising a variety of land uses (e.g. offices, retail and residential) designed to maximise access to public transport and often include features to encourage transit ridership; through the deliberate positioning of public transport services within walking distance for all residents and the encouragement of non-motorised transport modes through appropriate design features. An example of the TOD-neighbourhood concept and TOD-citywide concept is summarised in **Figures 2.1** and **2.2**.

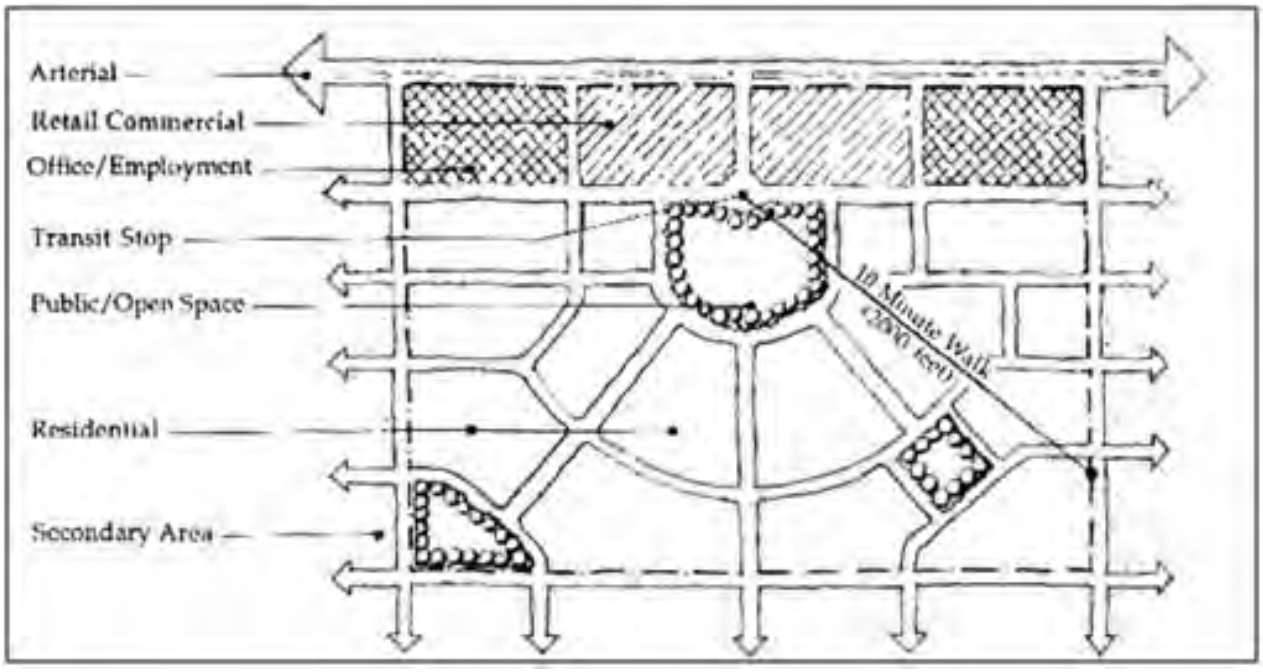

Figure 2.1: The TOD Neighbourhood Concept Source: Katz 1994

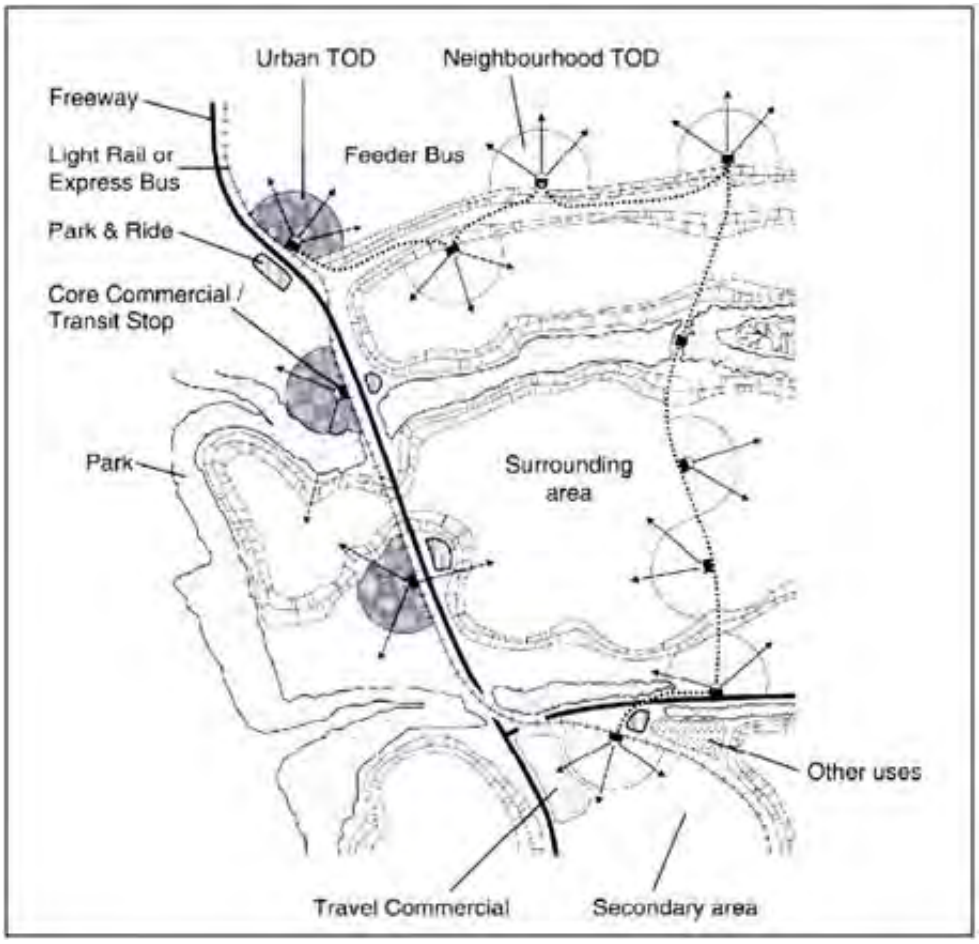

Figure 2.2: TOD in a City-wide Context Source: Hall and Ward 1998

The benefits of implementing a TOD approach are varied and range across the land use system and transport system, at both a local and a city-wide scale. Wilkinson (2006) summarised these benefits as follows:

- The enhanced accessibility of TOD neighbourhoods may be capitalised as increased land values and rentals in both residential and commercial property markets (TRB, 2002).
- Reduced per capita motor vehicle travel in successful TOD neighbourhoods, manifested in lower city-wide aggregate vehicle kilometres travelled (VKT), reduces overall road congestion levels and travel times, with beneficial environmental consequences in the form of reduced fuel consumption and exhaust emissions (VTPI, 2005; TRB, 2002).
- TOD neighbourhood residents are more likely to use public transport services easily accessible to them, increasing ridership levels and improving levels of operating cost recovery through the farebox (TRB, 2002; VTPI, 2005).
- Proximity to public transport services improve the mobility of TOD neighbourhood residents without access to private vehicles who, in conventional suburban developments might be regarded as “transport disadvantaged” (VTPI, 2005).

- The design of TOD neighbourhoods, in particular the provision made in their layouts for walking and cycling movements, enhances their general liveability and may also promote healthier lifestyles (VTPI, 2005).

It is worth noting, however, that the benefits described above have been developed in the context of North American urban development trends and conditions and as such, these benefits might not translate accordingly in a South African context.

TOD – the South African and Cape Town Context

Three of the National Government's *Priority Outcomes* as presented in the *Medium Term Strategic Framework* (2014 to 2019) speak to TOD, namely:

- Outcome 6: An effective, competitive and responsive economic infrastructure network.
- Outcome 8: Sustainable human settlements and an improved quality of household life.
- Outcome 9: Responsive, accountable, effective and efficient local government system.

Furthermore, the Transport for Cape Town's *Integrated Public Transport Network Plan 2032* (2014) highlights the 5 transport-related TOD principles:

- Affordability – reduce the cost of public transport to commuters and the cost of providing public transport to the City.
- Accessibility – facilitate equal access to social and economic activity through strategic urban development and the provision of safe public transport.
- Efficiency – provide an environment and level of service that reduces trip lengths and dependence on private vehicles.
- Intensification and Densification - manage the desired form, composition and location of urban development to make affordable, accessible and efficient public transport viable.

The above shows that TOD is a development strategy with a focus on viable public transport and, therefore, incorporates urban form, as well as development type, intensity and mix. As such, the transport system must respond to urban development in a way that caters to the needs of passengers while still being affordable to its residents and financially viable (relatively speaking) for the City. A strong relationship between public transport and urban development is a necessity to ensure the success of this strategy, with the provision of public transport used proactively to drive sustainable and compact development (IPTN, 2014).

TCT has, therefore, decided that TOD, as it applies to Cape Town, is proposed as the best long term development strategy to address spatial inequality, transport affordability and to arrest sprawl, as it is driven by the integration of sustainable public transport and strategic

land use intervention and built on the principles of affordability, accessibility, efficiency, intensification and densification (IPTN, 2014). As such, two different TOD scenarios were tested as part of the City's IPTN model, namely "Pragmatic TOD" and "TOD Comprehensive" and concluded inter alia:

> *"The potential long-term sustainability benefits to the public transport network of moving towards a transit oriented development approach to land use planning is significant and, therefore, the City should adopt the principles of Transit Oriented Development as outlined above and work towards implementing mechanisms to encourage TOD. Should development not occur in the transit-oriented way indicated in the land use scenario in the future, the public transport network developed in this project will not be the optimal network for that future picture".*

Furthermore, the report recommends that the preferred IPTN Transport Network alternative is assessed on either the "business as usual" or "TOD comprehensive" scenarios, which infers that the public transport network has been planned for TOD, as it is unreasonable to think that "business as usual" will prevail within Cape Town for the next 20 years.

Discussion

TCT is intent on pursuing TOD as the preferred land use strategy for the City's long-term future and as such, has developed the IPTN based on this approach. Although the majority of literature regarding the benefits of TOD have been developed from the North American context, it is reasonable to assume that most of these findings should hold true in most contexts. It is, therefore, realistic to assume a shift in modal split; towards a greater public transport and non-motorised transport share.

In addition, although one could expect an increase in the number of vehicle trips, these would be confined to a local area, characterised by high density mixed land use, with a decrease in the amount of vehicle kilometres travelled expected. This will result in less congested conditions on freeways, highways and certain arterial roads and it could be argued that these conditions will make rat-running less appealing and we can expect a gradual reduction in rat-running traffic over time as the land use strategy as rolled out.

2.5.3 Proposed Redevelopment of District Six

The previous sub-chapter discussed the City's long-term plans to implement TOD as the preferred land use strategy for Cape Town's. It should be noted that, although well-defined, the goals and implementation of this strategy are currently somewhat high-level, due to this being a relatively recent decision (to implement) and the fact that the strategy speaks to the

whole of Cape Town. It is, therefore, important to investigate on a micro-scale what is proposed within / within the immediate vicinity of the study area in an attempt to understand the future implications of these on the transport network.

Background

District Six is located in the City Bowl, between the suburbs of Zonnebloem and Walmer Estate as shown in **Figure 2.3**. The suburb was previously a residential area and is characterised by the forced removal of approximately 60 000 inhabitants and subsequent relocation to the Cape Flats under the Group Areas Act of the previous Apartheid regime. The existing buildings were bulldozed (with the exception of places of worship), although international and local pressure made redevelopment difficulty for the government. The Cape Peninsular University of Technology (previously Cape Technikon) was however, built on a portion of District Six (on the corner of Keizersgracht and Tennant Street).

After the fall of the Apartheid regime and subsequent elections in 1994, the South African government decided to recognise the land claims of the previous residents of this area and pledged to support rebuilding. It should be noted that as a result of political friction between the previous residents, local government and the national government, the City of Cape Town is not driving the land restitution claims process and redevelopment of District 6; this process is being driven by National Government via the Land Claims Commission. At the time of writing this process was still ongoing; however, significant planning has been undertaken regarding the proposed redevelopment of this site as discussed in the next section. In addition, only 40 000 residents will be able to be accommodated due to the land lost to the University.

Cape Town Spatial Development Framework

The Cape Town Spatial Development Framework (2012) is a long-term (20 year) statutory plan to manage and guide urban growth within Cape Town and follows a pre-defined set of goals and (legally) mandated principles. Information from this document feeds into District Spatial Development Plans which look at the medium term (10 years future), which in turn feeds into Local Spatial Plans.

Due to the high-level nature of this document, not much detail is provided on the intention to redevelop the District Six area however, *Map 6.1* shows that this area has been earmarked as one of the sites for future urban development. It is worth noting however, that for both future scenarios tested in the IPTN, the densification of the District Six area was included.

Figure 2.3: Location of District Six

Source: Google Earth

Table Bay District Plan

The Table Bay District Plan (2012) is a spatial development plan and environmental framework prepared by the City of Cape Town for the Table Bay District (which includes the District Six area, Walmer Estate and the CBD). The district plan forms one of 8 plans developed for each of the planning districts of the City of Cape Town, all of them informed by the city-wide CTSDF. This plan is a medium term plan (i.e. developed on a +/- 10 year planning frame) that will guide spatial development processes within the district.

The plan describes a "multi-directional accessibility grid" as part of the prevailing spatial structure for the district, with the aim of the grid to *"facilitate convenient access and multidirectional movement between the district and other parts of the city ("primary accessibility grid") and within the district ("secondary accessibility grid") which will feed the primary grid."* As such the plan establishes the alignment and hierarchy of the accessibility grid, describes the areas of intensification and provides an indication of the type of transit station precinct typology depending on location.

The district plan identifies that the potential exists for significant Greenfield development (currently undeveloped land) in District Six which will provide public and economic facilities. It does concede, however, that the drawn-out development processes and institutional complexity attributed to the land redistribution process severely limits urban growth and renewal for this site.

The proposed spatial development plan for the Table Bay District is shown in **Figure 2.4**, with the District Six area indicated in yellow. The plan assumes this area to comprise mixed land use and residential uses (medium and high density) with an approximate yield of between 4 500 and 5 000 dwelling units and will, generally, be categorised as high density development. In addition the district plan provides guidance for new development areas, specifically District Six that includes, inter alia:

- Supporting a mix of land uses, with areas of high density concentrated along the major street and other points of high accessibility.
- Establish Keizersgracht as an important linkage and reinforce gateways into District Six.
- Allow higher density development along Keizersgracht as an activity street.
- Establish a pedestrian link along Keizersgracht that connects the area to the East City.

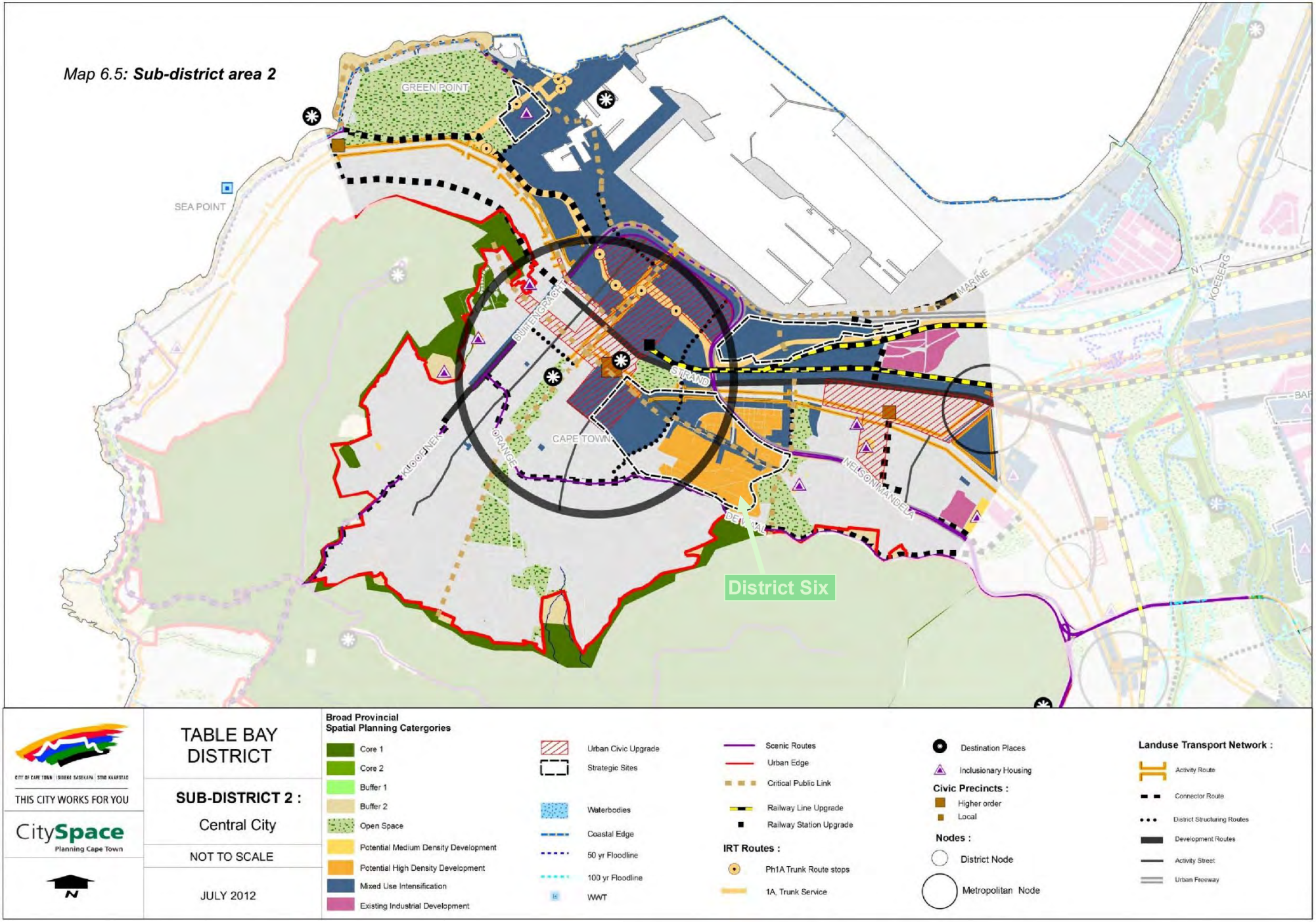

Figure 2.4: Table Bay District – Spatial development plan

Source: Table Bay District Plan (2012)

District Six Development Framework

The District Six Development Framework (2012) presents a set of principles, strategies, design and planning guidelines; as well as infrastructure proposals based on the existing inner city context of the site. The purpose of this document is therefore to plan the development of District Six, taking into account the over-arching guidelines and principles for the future planning of the City (presented in the CTSDF) as well as those envisaged for the future planning within the affected district (Table Bay District Plan). The framework has a significant amount of information regarding the planning process (e.g. vision for the site, stakeholder engagement, etc.); however, this section will only highlight key features that are expected to influence the Walmer Estate study area.

The framework proposes a number of different street typologies (road hierarchy network) for the area, as shown in **Figure 2.5** of which Keizersgracht (New Hanover Street) has been identified to be the activity spine for the entire development. It is envisaged that the road would be similar to Sea Point Main Road in appearance and operation, with the narrow lane widths and regular intersections serving to slow traffic and discourage rat-running in the area.

It is, therefore, proposed that this road has only one lane per direction (i.e. narrowing of the existing road width and road reserve), with on-street parking on both sides of the road and will also include additional bus priority measures. It is further proposed that separate cycle lanes and pedestrian sidewalks are provided on either side of the road. The proposed cross-section of this road is shown in **Figure 2.6**.

Discussion

The District SIx area has been identified in both the CTSDF and Table Bay District Plan as an area for future medium-to high density mixed land use development, providing an additional 4 500 to 5 000 residential units. A hierarchical road network for the District Six area is proposed, with Keizersgracht identified as the activity spine of the entire development, defined by narrow road lane widths and an accompanying mix of travel modes with a focus on public transport.

The proposed development of District Six is expected to have a significant effect on traffic flow on the surrounding road network as the area is currently (mostly) undeveloped and any development that takes place will therefore add vehicles and in most cases additional components (accesses and roads) to the road network.

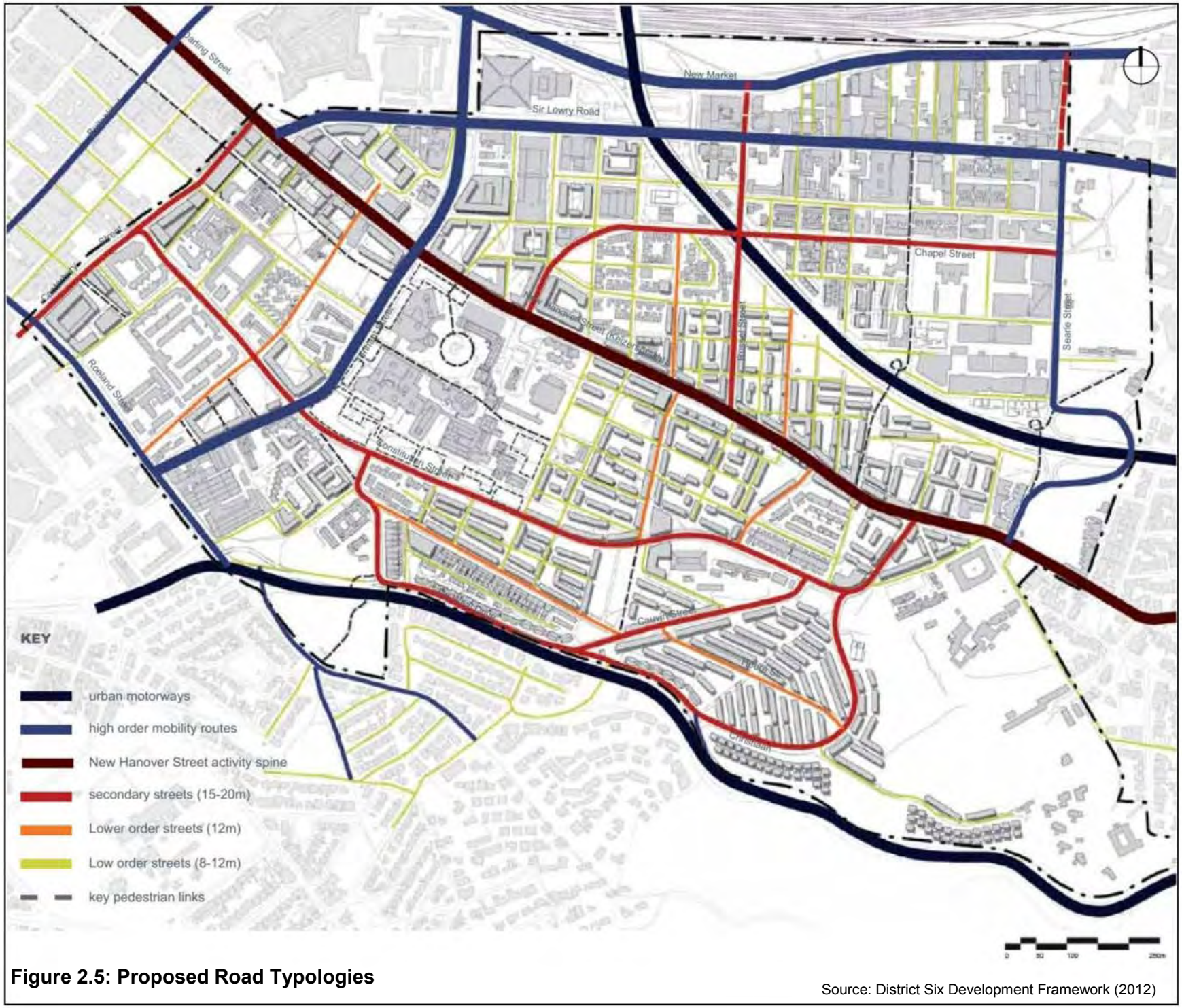

Figure 2.5: Proposed Road Typologies

Source: District Six Development Framework (2012)

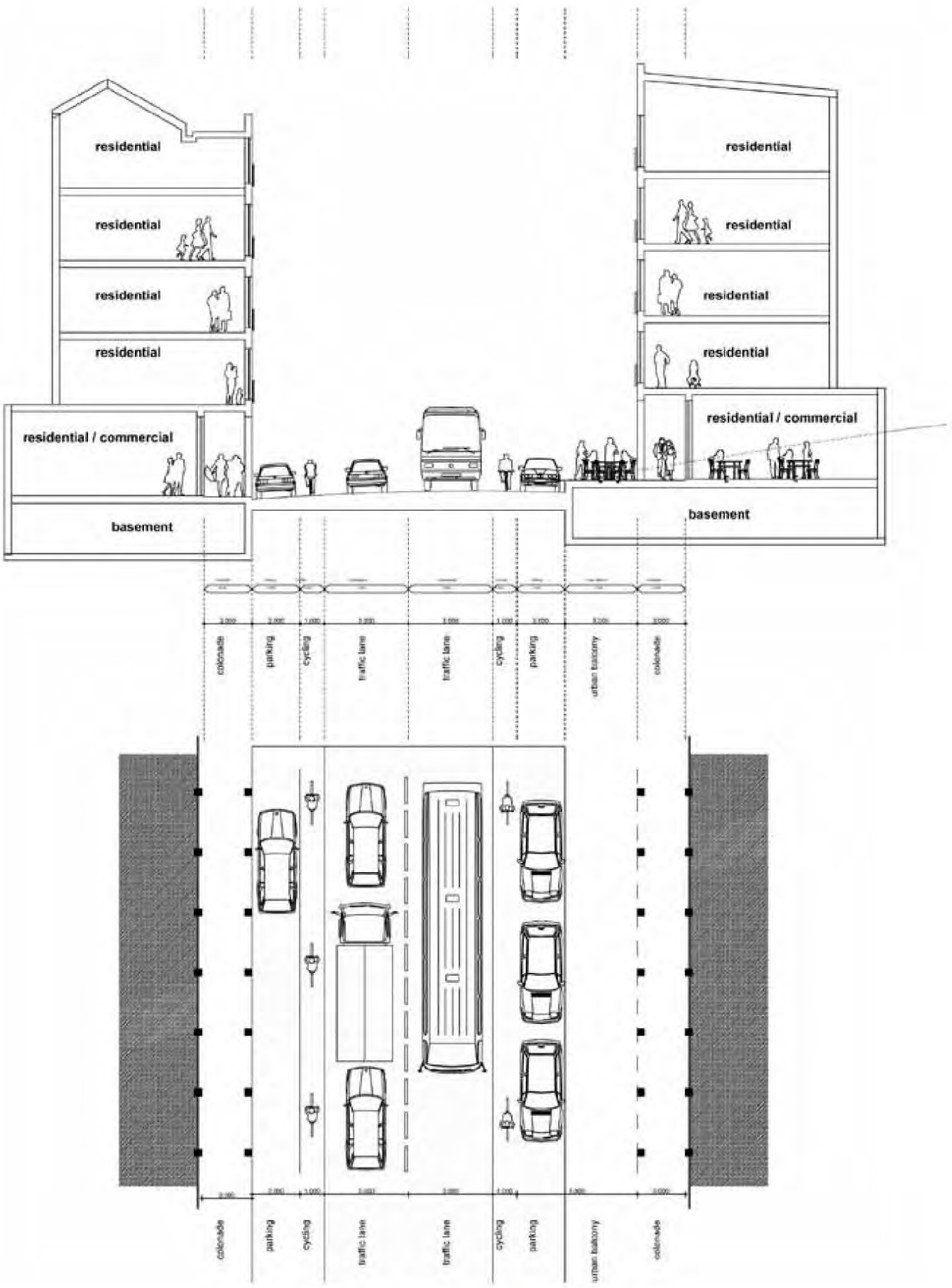

Figure 2.6: Proposed Keizersgracht Cross-section

Source: District Six Development Framework (2012)

In the case of the ultimate development scenario, in line with the previous discussion regarding TOD, one would expect an increase in localised congestion within the development. These local traffic conditions, combined with the cross-section proposed for Keizersgracht is expected to significantly reduce the number of rat-runners making use of the existing rat-run route through Walmer Estate via Keizersgracht as a result of increased travel time, increase effort, etc.

Cognisance is taken of the fact that the land claims restitution process for District Six is still underway no foreseeable end in the short-term, meaning that the actual development will only begin in the medium term, with the ultimate development competed in the long term. Since this development has, however, been included in the CTSDF, IPTN planning scenarios, Table Bay District Plan and a development framework for the site has been completed, one can be relatively certain that the development will be completed, albeit later than what was originally anticipated.

2.6 Short-term Solutions for Reducing Rat-running Volumes

While the previous section explored land use planning as a tool to alter traffic behaviour on a road network and in so doing, cause a decline in rat-running; this is something that can only be implemented in the medium to long term, due to the time and coordination required for successful implementation. There are, however, short-term solutions i.e. that can be implemented within a few weeks or months, that can be effective in reducing the number of rat-runners making use of a particular route. It should be noted that Taniguchi, Grääs and Friman (2014) classifies two different types of measures:

- Hard policy measures – comprise measures, such as changes to infrastructure and it is noted that while these changes have the intended effect, they are costly and not always politically feasible.
- Soft policy measures – comprise measures, such as an information campaign to change driver behaviour and it is noted that these measures are "generally effective".

This chapter explores typical examples of these types of measures and discusses the efficacy of each.

2.6.1 Physical Measures

Rat-running occurs when motorists attempt to avoid congestion or delays by taking secondary routes that can offer reduced travel times or in some cases, a shorter (albeit more onerous) route. It then stands to reason that towns and cities have traditionally endeavoured to reduce the number of vehicles rat-running by either attempting to increase the travel time on these routes or by making the route more onerous / stressful to navigate, thus making the route less appealing to potential rat-runners. This is illustrated in a study by Legrain, Eluru and El-Geneidy (2015) that concludes that driving (private car travel) is the most stressful travel mode. In using the concepts discussed regarding route choice theory, one can infer that making a particular route more stressful may result in a choice trigger, altering a change in route choice and forcing the motorist back to an ultimately less stressful route. Furthermore, a study by Garrod, Scarpa and Willis (2002) concludes that drivers experience a loss in utility due to the effects of traffic calming measures on their journeys. Route choice theory therefore proposes that in some cases, this loss in utility may be substantial enough to force a driver to choose a more beneficial route.

Reducing through traffic is typically achieved through the implementation of vertical and horizontal deflection measures (traffic calming measures) as discussed in the next sections.

Vertical Deflection

A vertical deflection measure temporarily lifts a moving vehicle a nominal amount above normal road height (e.g. 100mm) in such a manner that upon approach, the vehicle has to slow down before traversing the measure. Examples of these measures include, but are not limited to:

- Speed bumps / humps.
- Speed cushions.
- Speed tables.
- Raised intersections and raised pedestrian crossings.
- Changing the texture of the road surface (e.g. cobblestones).

Numerous case studies have shown that the introduction of vertical deflection measures results in a decrease in vehicle speed along the treated section of road. This decrease in speed increases pedestrian safety and, significantly, reduces pedestrian fatalities (since pedestrian fatalities increase exponentially with speed). In addition a study by Crouse (2004) shows that each 1mph reduction in speed results in a 5% reduction in collisions. There are, however, some disadvantages associated with vertical deflection measures, as reported by Jobanputra (2012): they force emergency vehicles to travel at slower speeds, they cause a rough ride for all passengers and they can have effects on surface drainage.

Horizontal Deflection

Horizontal deflection measures are physical measures that force a vehicle to shift from its “normal” travelled path and in doing so, not only requires approaching vehicles to reduce in speed to successfully navigate through the measure, but also draws driver attention to the change in road environment. Examples of these measures include, but are not limited to:

- Chicanes.
- Pedestrian refuges / bump outs.
- Curb extensions (bulb-outs).
- Chokers.

The advantages of these measures are similar to those of vertical deflection measures, with the added benefit that there is less of an impact on emergency vehicles as they are able to “bypass” these measures. Jobanputra (2012), states that the disadvantages of these measures include, possible surface drainage issues and the potential elimination of on-street parking.

Discussion

These short-term measures are relatively inexpensive to construct and can, generally, be applied to any situation. The implementation of these measures is, therefore, common in many suburbs throughout Cape Town. Furthermore, these measures can easily be added to existing roadways, without any significant geometric changes to the existing road required and they do not result in a redistribution of traffic by preventing vehicles from using the treated road. Examples of both types of measures are shown in **Figure 2.7**. There is, however, always a risk that implementing traffic calming measures on a single road may simply lead to vehicles diverting to a parallel road and these measures are only ultimately effective when implemented as part of an area-wide scheme.

It is worth noting that the implementation of these measures within a suburb (in Cape Town) usually requires some form of public participation from the affected community, although Garrod, Scarpa and Willis (2002) states that it is impossible to chose a universally accepted traffic calming scheme as individual tastes vary.

In addition, Garrod, Scarpa and Willis (2002) conclude that residents staying closer to a treated road enjoy most of the benefits and Crouse (2004) maintains that traffic calming schemes can have a positive economic effect on the affected neighbourhood, as house prices go up as vehicle volumes decline.

It is important to understand that ideally traffic calming should be viewed as an interim or complimentary solution, since it is employed in an effort to solve a specific problem, without addressing the root cause. To this extent, the role of land use and land use planning was discussed at length in earlier chapters, as these two components i.e. land use planning and traffic calming measures are complimentary and, therefore, work best when implemented as part of a holistic plan in changing drivers' perceptions and behaviours.

Horizontal Deflection Measures

Vertical Deflection Measures

Figure 2.7: Examples of Vertical and Horizontal Deflection Measures

Intersection Geometry Changes

In addition to implementing traffic calming measures along the length of a road or as part of an area-wide scheme for a road network, it is also possible to alter the geometry of intersections to reduce the amount of through traffic making use of a particular road. Some examples of these measures are listed below and shown in **Figure 2.8**:

- Diagonal diverters.
- Half-closures and full closures.
- Lateral shifts.
- Median barriers.

From Jobanputra's (2012) study, it is possible to infer that there are some common advantages as a result of the implementation of the above measures e.g. they are effective in reducing through traffic volumes (ie rat-runners) and they are able to maintain bicycle and pedestrian access. Some of the disadvantages of these measures include creating circuitous routes for local residents and emergency services, cost and possible land appropriation issues. An additional disadvantage may result from the redistribution of traffic following the implementation of these measures, where traffic patterns shift in accordance to the measure, causing once quiet streets to experience a permanent increase in traffic volumes.

Discussion

It is logical to conclude that the above measures should have a greater impact on reducing through traffic volumes due to their physically imposing nature. It should be noted, however, that unlike horizontal and vertical deflection measures, these measures can only be constructed at certain intersections due to space constraints, as well as constraints related to the function of the measure.

Furthermore, the traffic redistribution effect of the proposed measure has to be carefully considered prior to construction as in most cases, vehicles are physically diverted to an alternate (perhaps lesser used) route and ideally, a period of monitoring subsequent to the introduction of these measures should be undertaken (once traffic patterns have stabilised) to quantify the effects of this redistribution. Lastly, these measures cannot generally be placed in such a way that they interfere with an existing public transport route as this will force a diversion of these services.

Figure 2.8: Examples of Intersection Geometry Changes

Other Measures

In addition to the above physical measures, “philosophy” based street treatments can also be applied to a suburb to induce traffic calming. An example of this is the Dutch-style woonerf, which is regarded as a “living street” where shared space between pedestrians and vehicles is promoted. Although originally developed in the Netherlands, the efficacy of this type of street-treatment has resulted in variations spreading throughout the world; with countries in North America, Europe and Oceania all adopting this approach as required. The speed of vehicles travelling through these areas is restricted to that of a walking pace (NMIE, 2015), typically through the implementation of traffic calming measures, landscaping, street furniture, geometric retrofitting and the creating of pedestrian-friendly spaces as shown in **Figure 2.9**.

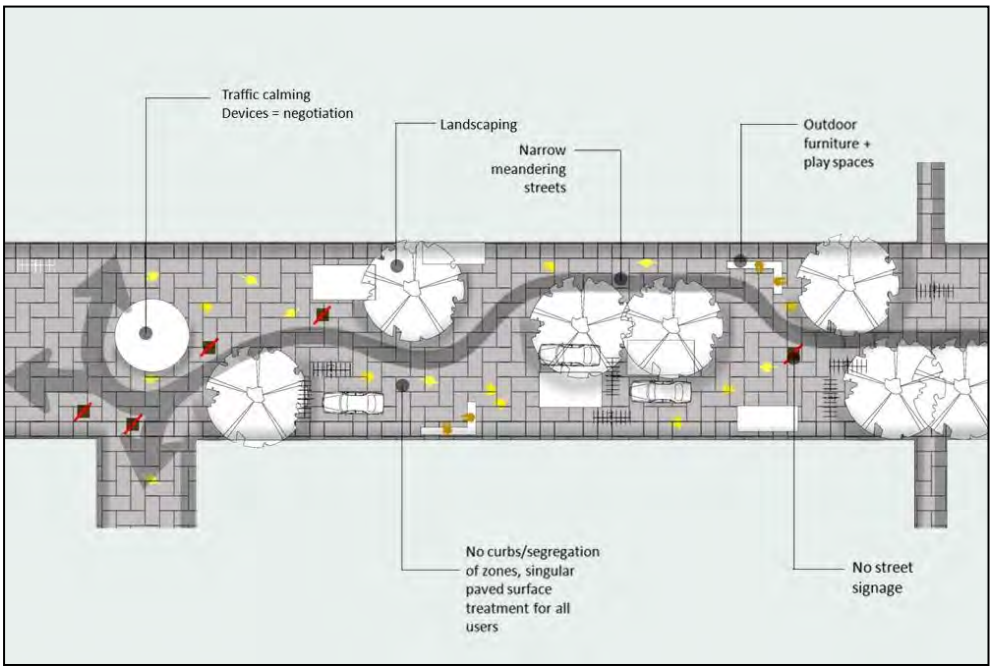

Figure 2.9: Example of a Woonerf Treatment Source: www.streetswithoutcars.wordpress.com

For the purposes of this study, there are a number of advantages of implementing this type of calming treatment including:

- Allows the affected community the opportunity to “reclaim” the streets through the creation of pedestrian-friendly spaces and appropriate geometric design, resulting in a “happier” community.
- Does not require active enforcement by traffic officers to ensure compliance due to the nature of its design e.g. it is extremely unlikely that passing vehicles can travel at excessive speeds due to the curved line of travel created by obstructions.
- The various obstructions demand extra vigilance from drivers when compared to “regular” traffic calmed streets.

- The driver's extra vigilance, combined with the low travel speeds of vehicles moving through the woonerf, facilitates and encourages eye-contact between motorists and pedestrians and serves as a reminder of the relationship between residents (people) and the movement of vehicles through their area.

It should be noted that although this type of calming treatment is not normally implemented across the country at present, the South African National Department of Transport has developed a regulatory sign for a woonerf and has included being able to identify the sign (and its purpose) as one of the many signs learner drivers need to revise as part of their learner driver's test (National Department of Transport, 2012). Their description of the sign is shown in **Figure 2.10**.

Name:	Woonerf (R403)
Where:	On any public road.
Purpose:	To prohibit the entry of all vehicles with a mass exceeding 3 500 kg, or vehicles, which have more than 10 seats, except for local access or delivery.
	• To yield right of way to pedestrians in the street.
	• To prohibit vehicles from driving through the area without breaking their journey.
	• To limit the speed of vehicles in the area to 30km/h
Action:	Drive slowly, obey the special rules mentioned above and be particularly on the look out for children playing in the street.

Figure 2.10: Woonerf Regulatory Sign Description Source: National Department of Transport (2012)

Furthermore, various institutional publications acknowledge the potential of the woonerf concept for South African suburbs and provide some high level guidance as to their design considerations and implementation, e.g. City of Cape Town's *Minimum Standards for Civil Engineering Services in Townships* (July 2013) and *Guidelines for Human Settlement Planning and Design* (2005) compiled by CSIR under the patronage of the Department of Housing. The possible introduction of woonerf calming treatments for East West linkages within the Milnerton area has also been identified in the City of Cape Town's *Milnerton South – Paarden Eiland Local Area Spatial Development Framework* (2013).

Discussion

The implementation of woonerf-style treatments in areas as a response to rat-running has proved to be successful throughout the world. This form of calming treatment has numerous benefits that serve to enhance the community and completely change the existing traffic situation, while requiring minimal enforcement by traffic officers. As this treatment works best when implemented throughout an affected area, there is a concern

regarding implementation costs. In addition, space constraints dictated by the existing cadastral boundaries may result in a need for alternative solutions to be considered.

2.6.2 Non-physical Measures

There are a small number of non-physical measures (excluding effective land-use planning) that can be pursued in an attempt to reduce through traffic volumes as listed below:

- Road signage (i.e. prohibiting through-fare of vehicles).
- Information campaigns aimed at those rat-running.
- Intelligent transport systems (ITS) and variable message signs used to convey information e.g. travel time to motorists.
- Travel demand measures (e.g. flexi-time for workers).

It should be noted that although the above measures can be considered as generally effective, they do not offer the same assurances as physical measures, as a result of possible lead time in uptake (i.e. delayed impact), willingness of motorists to change and in the case of road signage, effective enforcement can be an issue.

2.6.3 Other Measures

There are two other measures that can be used to reduce through traffic volumes, that don't necessarily fit into any of the above categories and they are discussed below.

One-way Conversions

In some cases, depending on the layout of the road network, it may be possible to decrease through traffic volumes in a particular area by converting an existing two-way road into a one-way roadway, or by changing the direction of an existing one-way roadway. It should be noted, that in Cape Town, these proposed conversions (assuming the road is legally wide enough to operate as a two-way roadway) are required to be advertised and involves a public participation process with the affected parties. While we can assume that most residents would be in favour of such a conversion, the outcome is still based on the consensus of the affected community. Before proposing such a conversion, it is also important to consider existing public transport services that may be affected by the change.

Ramp Metering

A ramp meter is a device comprising a basic traffic signal light (i.e. red and green only, no amber) and a signal controller, that regulates the flow of traffic entering (typically) freeways, depending on current traffic conditions. Unlike normal traffic signals that provide long periods of green time, these systems typically only allow between one and three vehicles to enter a system at any given time. The signal controller receives information from induction

loops placed on either side of the on-ramp, detecting the number of vehicles and the average speed of the vehicles travelling on the motorway. Once a pre-defined threshold value is exceeded, a signal is relayed to the signal controller, which activates the traffic signal.

Although not typically used for rat-running, ramp meters have been used for this purpose to great effect in the Netherlands, with the first ramp meter system implemented in 1989 in response to rat-runners; with follow up studies showing an increase in average speed on the motorway, coinciding with a decrease in the number of rat-runners as a result of the implantation of the ramp meter (Middelham and Taale, 2006).

The benefit of this system is that it only becomes operational once certain threshold values are exceeded; thus an onramp can function as before during off-peak times. Furthermore, the ramp metering system has a positive effect on traffic flow on the motorway as it effectively prevents a significant amount of vehicles from attempting to enter the motorway at a point perceived to be downstream of congestion. This reduces the delay currently experienced in the vicinity of the onramp and therefore increases the average speed of the vehicles, in effect increasing capacity.

This will most likely result in an ideal scenario where rat-runners return to making use of the motorway due to the improved travel times offered and as a worst-case scenario, will force rat-runners to a different route as a result of the significant delay imparted by the ramp meters at the onramps.

2.7 Unclassed Matters for Review

There are a number of additional matters related to rat-running that cannot be classed under any of the above sub-chapter headings, but need to be discussed in the literature review section. This sub-chapter therefore serves to group all of these additional matters with a discussion related to each, provided below.

2.7.1 National Department of Transport's Proposed Draft Regulations

The National Minister of Transport has drafted a number of proposed regulations (National Department of Transport, 2015), for discussion, that if implemented may impact congestion and therefore rat-running. The proposed regulations that may impact congestion are listed below:

- No more than five people to be carried in a bakkie load bed.
- Children not to be transported in a bakkie load bed.
- Speed limits to be reduced from 60 km / hr to 40 km / hr in urban areas.
- Goods vehicles above 9 000kg GVM to be banned from public roads during peak travelling times.

It should be noted that, since these proposed regulations are still in draft format, it is difficult to predict whether they will be accepted by parliament and in what form and as such, it is tricky to estimate their actual impact. It is important, however, that for the purpose of this study they be acknowledged.

It is possible that the regulations related to the transporting of passengers in a bakkie load bed may lead to an increase in vehicle traffic; however, this is not expected to have a significant impact of vehicle volumes and rat-running traffic in the study area and immediate vicinity. These proposed regulations are expected to have a greater impact on rural transport.

A reduction in the urban area speed limit to 40 km/hr is unlikely to have a significant impact on vehicle flow during peak times, since posted speed limits have little effect on driving speed (Archer, et al, 2008) during these periods. This is because, during these heavily congested periods, drivers very rarely have the opportunity to travel at the posted speed limit due to the slow moving nature of the congestion.

The banning of large (heavy) vehicles from the roads during peak periods will most likely create additional capacity, which may draw rat-runners back to the highways. This occurrence would be most pronounced adjacent to major haulage routes (i.e. the N1) and is

anticipated to only have a relatively minor impact for vehicles currently rat-running through Walmer Estate (due to its distance from the N1).

2.7.2 Smart-phone "congestion-beating" Applications

With the advent of smart-phones and mobile technology, new phone-based applications have been developed that make use of the GPS functionality contained within these devices to pinpoint a user's location on the existing road network while logging their travel time; with users also given the opportunity to log incidents such as traffic collisions. This data is collected in real-time to provide an output, navigating users of this service onto routes that at that specific moment in time reflect the shortest travel time between their origin and pre-selected destination.

The most popular of these applications is called "Waze" and is marketed as a "*community based traffic and navigation app*". The app was launched in South Africa in 2012 and, while not much information is available pertaining to South Africa regarding the number of users, recent reports indicate that the application has logged over 10 million travelled vehicle kilometres in South Africa (*www.thetechieguy.com*, 2015) and is ranked in the top 100 apps on the South African iTunes charts (ahead of Trip Advisor). This infers that the application is growing in popularity, although one would expect the majority of users to be based in Johannesburg.

While the technology and the innovation involved in the development of these sorts of mobile applications should be lauded, one should remain suspicious as to the overall effect they have on communities. It is logical to infer that the application calculates the optimal route (i.e. the route with the shortest travel time) by making use of all roads comprising the road network. As such, residential roads are now being used by "outsiders" during peak periods in an attempt to avoid congestion, i.e. rat-running. This has been acknowledged by councillors in cities such as Los Angeles (Barragan, 2015), where the app has proved extremely popular due to extreme congestion issues, through the attempt to ban the inclusion of residential roads on the applications' road database due to rat-running concerns.

It is important to note that while certain measures can be implemented to make certain rat-running routes more onerous for regular users; new technology is now actively promoting the existence of these routes to an entirely new group of potential users. This may actually lead to a greater increase in through-traffic volumes, regardless of mitigating measures that may have been installed to deter rat-runners; until such time as "true" equilibrium is reached across the road network (i.e. travel time on all routes is the same).

2.7.3 Previously Proposed Mitigating Measures and Community Sentiment

As part of the literature review, it is important to detail the community's sentiment with regard to the existing rat-running problem. Although this is not an accurate measure as to the true extent of the problem since affected residents are likely to exaggerate vehicle volumes, this information can provide greater insight into the effect that this practice has on these communities as well as important details regarding the behaviour of the rat-runners (i.e. quantifying the unquantifiable).

Furthermore, it is also essential to document the steps taken to date by the City in an attempt to mitigate this problem, as this enables a high-level efficacy assessment of these measures and may provide greater insight into developing a final solution to this specific rat-running problem. Information has been obtained from various news articles and a brief timeline overview is provided below.

2011

An article from November 2011, appearing on the Upper Woodstock Residents Association website (Hislop, 2011) states that representatives from the City's Roads Department met with the affected residents and civic bodies "...*after years of complaints*," to present three possible solutions to the existing rat-running problem. An overview of these three options is provided below:

- A manned boom placed across Chester Road, in the vicinity of the Keizersgracht intersection to block-off all traffic except emergency vehicles, which would become operational between 16:00 and 18:00 on weekdays.
- Regulatory signage placed on the corner of the Chester Road / Searle Street / Keizersgracht intersection making it illegal for anyone to enter the area between 16:00 and 18:00 on weekdays – this would require regular law enforcement.
- Regulatory signage (similar to the above) placed inside the suburb at strategic points, allowing for residents to enter the area but envisaged to prevent rat-runners from cutting through the area – this would require regular law enforcement.

It should be noted that at this meeting, Councillor Herron conceded that the state of Traffic Services within the City was "poor", although he added that this problem was in the process of being addressed. From an outsider's perspective this is alarming, as two of the three proposed options presented to the residents rely heavily on effective and regular law enforcement to curb the rat-runners.

2012

An editorial from November 2012, published in the People's Post Newspaper maintains that residents of Walmer Estate are concerned that the City had still not addressed the rat-running issue, even as they were in the process of rolling-out MyCiTi bus services to the area. The Walmer Estate Resident's Community Forum was established as a task team to investigate the current rat-running problems and propose solutions to these problems. The Forum proposed the following solutions:

- The implementation of traffic calming measures on Lever Street.
- A manned boom placed across Chester Road, in the vicinity of the Keizersgracht intersection which would become operational between 15:30 and 18:00 on weekdays.

The chairperson of the Forum went on to comment that "...*the City is also legally bound to address the high volume of traffic on this route during these hours, for which it is not designed*." At the time of going to print, the report had not managed to receive a response from City officials.

2013

An article from June 2013, appearing in the People's Post Newspaper states that City developed a new proposal to alleviate the existing rat-running problems experienced in Walmer Estate. This was presented to the residents at a meeting and opened for formal public comment. The City's proposal was to effectively ban all traffic travelling away from the City on Keizersgracht from accessing Chester Street by way of road signage, forcing them to turn left into Searle Street, while maintaining the existing movements on the Searle Street approach (i.e. the left turn from Searle Street into Chester Street).

A representative from the City explained that this proposal would still allow residents to access the area (via Searle Street), but would make it inconvenient for rat-runners to move through the area. Some residents, however, indicated that this would also inconvenience residents, as they would have to mix with general traffic on Searle Street and also raised concerns that this measure could lead to the formation of new rat-run routes through Upper Woodstock.

In addition, residents voiced their concern at the existing problem stating "...*it affects us as a family. The number of vehicles flowing through Coronation Road is alarming, creating noise and adding air pollution. There are numerous motorists not adhering to the speed limit or stopping at the new stops. It gets so busy that there are times when you cannot cross the road*".

2014

The Cape Argus, originally, reported at the beginning of January 2014 (Nicholson, 2014) on the imminent implementation of the proposed rat-run mitigation measures by the City, as presented to the affected community in 2013. These measures would be implemented for a three month trial period between 16:00 and 18:00 on weekdays, with a City official being reported as stating the use of a proposed access permit system for residents was unfeasible. Residents were recorded as stating they were hopeful that the implementation of these measures would finally alleviate the many negative impacts brought about by the rat-running. Residents, however, raised additional concerns regarding the introduction of the MyCiTi bus service in the area stating that the service had worsened the existing situation.

The Cape Times followed up on events during the week of the proposed implementation (Nicholson, 2014). Residents revealed that the first day of the proposed implementation did not go as planned, as many traffic officers arrived late and were unprepared. A city official assured the residents that the implementation would go ahead the following day and would ensure that traffic officials would arrive fully briefed and on time. He went on to state that part of the plan involved educating motorists as to the proposed changes and the effects that rat-running was having on the residents of Walmer Estate.

In April 2014, three months after the implementation of the mitigating measures a follow up article appeared in Woodstock Life (Armstrong, 2014). The article explained that a total of 11 traffic fines had been handed out to motorists who disobeyed the restriction signs located at the Keizersgracht/Searle Street intersection, much to the bemusement of local residents. Residents complained that the lack of enforcement had effectively nullified the effect of the mitigating measures as illegal transgressors faced no recourse. It should be noted that in addition to the above proposals and public participation processes, a number of traffic calming measures have in the past been installed on certain roads within Walmer Estate as described below and shown in **Figure 2.11**:

- 2 x Speed humps on Upper Cambridge Road
- 7 x Speed humps on Chester Road
- 4 x Speed humps on Coronation Road
- 2 x Speed humps on Cambridge Street and 1 x raised pedestrian crossing

Figure 2.11: Location of Existing Traffic Calming Measures within the Study Area

Based on feedback from residents at the community meetings presented earlier in this chapter, it is inferred these measures do not have any impact in reducing the volume of rat-runners, though they may force them to drive more slowly when passing through the area.

Discussion

The City has engaged with the affected community in an attempt to find a solution to the proposed rat-running problem. A number of proposals were presented to the residents, however some of these that may have been most effective (e.g. erecting the boom) were not considered feasible for implementation. As such, restrictive signage placed on the corner of the Keizersgracht/Searle Street intersection preventing vehicles from travelling into Chester Road was selected as the preferred solution.

During the trial phase, the City (through traffic officials) attempted to educate drivers making use of the rat-run about the proposed new mitigating measures. A follow-up assessment as to the efficacy of these measures ultimately showed that the proposal had failed, as it proved difficult for traffic officers to adequately enforce the restrictions.

2.7.4 Law enforcement

A number of rat-run mitigating measures (e.g. restrictive signage) are dependent on corresponding effective enforcement provided by traffic officers. If the mitigating measures cannot successfully be enforced then they become ineffective, as was highlighted in the previous chapter which covered the City's attempts at mitigating the Walmer Estate rat-run. This is because the rat-runners can continue as before, without a real risk of facing repercussions (acting as a "trigger" in their route choice decision) that would have potentially otherwise caused them to reconsider their chosen route. In Cape Town, there are two types of officials who are responsible for traffic enforcement:

- Traffic officers whose sole responsibility is that of traffic enforcement.
- Metro police whose responsibilities include: traffic enforcement, by-law enforcement and crime prevention.

It is safe to assume that the majority of metro police officers will however be involved in preventing criminal activity, and are therefore expected to provide traffic enforcement assistance on a regular basis. As such, the responsibility of traffic enforcement is almost solely attributed to traffic officers within Cape Town.

Currently, the City of Cape Town has a compliment of 480 traffic officers, but it has been widely reported that additional funding has been provided to enlist a further 90 officers, resulting in a total of 570 traffic officers (Petersen, 2015). It should be noted that although

there is no national norm concerning the number of traffic officers required per 100 000 residents, England and Wales provide approximately 10 officers per 100 000 residents (BBC, 2015). The 2011 National Census revealed that there is over 3.74 million people residing in the City of Cape Town, which is equivalent to approximately 15 traffic officers per 100 000 residents, 50 percent more than what are provided in England and Wales.

It can be argued that the overall level of compliance by motorists with regard to obeying traffic laws in Cape Town is worse when compared to England and Wales, although it is acknowledged that traffic officers experience different challenges to their British counterparts (e.g. minibus taxis) and, therefore, more sought-after throughout the City. For this reason, it is considered unwise to rely solely on enforcement as a means to mitigate rat-running, as it is impossible to dedicate traffic officers exclusively to this exercise.

2.7.5 Public transport

This section is intended to serve as a brief overview of some key factors concerning the influence of public transport on rat-running. It is acknowledged that the MyCiTi service, currently, operates within the study area along Chester Road, Coronation Road and sections of Upper Mountain Road, Rhodes Avenue and Upper Roodebloem Road. The presence of this service alone however, is not expected to have any significant impact on existing traffic flow patterns in the area (and by extension the number of rat-runners), as the buses are not afforded any form of priority along this section of the route, which may have otherwise been experienced as a travel time increase for general traffic along these public transport routes.

Yet on a larger scale, an increase in the number of daily public transport commuters resulting from a modal shift (i.e. people switching from private transport to public transport) will bring about a decrease in the peak period traffic congestion levels experienced on the City's road network, as a result of increased occupancies typically associated with public transport vehicles. It is assumed that decreased congestion levels will, to an effect, mitigate the effects of rat-running through the creation of additional capacity and the subsequent attraction of motorists back to the higher order roads. While it may be difficult to predict what modal shift, if any, will occur within the City in future with any level of certainty; the following should be considered:

- The most recent daily modal split for passenger trips entering the CBD is approximately 63:37 in favour of private transport, which is roughly in line with the City's 2014 goal of 60:40. Although an exact number is not provided, the *ITP* states that City's short-to

medium term objective is to achieve a modal split away from private car usage towards public transport i.e. at least a 49:51 split in favour of public transport.

- The City's long-term land use planning is centred around TOD, which relies extensively on the effective provision of public transport services as an alternative to private car travel.

With the above in mind, it is realistic to predict that the future modal share of this City is likely to shift further in favour of public transport (that the current modal split, at least). Furthermore, it is also reasonable to assume, specifically in the context of the study area, that public transport (in isolation) will therefore at the very least have a slight-to moderate impact in reducing the number of rat-runners currently travelling through Walmer Estate during the PM peak period, in the medium-to long term future.

2.7.6 Environmental Capacity of Roadways

When assessing the overall impact that rat-run volumes have on an affected road network and by association, the community, it is important to understand the difference between the absolute carrying capacity of a road and its environmental capacity. The carrying capacity of a road relates to the total number of vehicles per hour that can travel along a certain section of the roadway, while still operating at an acceptable level of service. It can be argued, however, that this type of threshold value is far more applicable to higher order roads (e.g. freeways, highways arterials and local distributors) than local residential roads, due to the unique characteristics intrinsic to class 5 roads, e.g. number of available access opportunities, mix of potential road users (including pedestrians), on-street parking provision, etc.

The concept of "environmental capacity" was first raised by Buchanan (1963) where it was suggested that as traffic increased, the assessment of a road's environmental capacity would become more significant. Buchanan recognised that traffic on residential streets affect the surrounding environment in many ways, including noise, vehicle fumes and increased pedestrian safety. Initial attempts made by Buchanan to quantify this concept were based on level of delay imposed on a pedestrian attempting to cross the road, a method which was further refined by determining the proportion of vulnerable pedestrians (e.g. elderly, children, etc) as well as the existing road environment (e.g. on-street parking). Using this method, Buchanan surveyed a number of residential streets (covering a range of traffic flow volumes) and was able to derive a series of graphs that made it possible to determine the environmental capacity for any roadway width and road roadway environment.

Subsequent to Buchanan's study, Appleyard (1981) conducted his own study on liveable streets, comparing three residential streets of similar characteristics, but with vastly different traffic flow volumes. The street carrying the most traffic was found to have a profoundly negative social effect on the residents (although the converse was also found to be true); with the road being perceived as a boundary, limiting daily interactions between community members

The environmental capacity of a road thus does not specifically relate to the absolute traffic carrying capacity of the road but is described by O'Flaherty (1996) in *Transport Planning and Traffic Engineering* as:

> *"...the capacity of a street or area to accommodate moving and stationary vehicles having regard to the need to maintain (chosen) environmental standards. In other words, environmental capacity is the upper limit of traffic volume that is permitted on the road(s) in question without exceeding desired minimum standards related to, say, noise, air pollution, pedestrian and cyclist safety and amenity, and visual intrusion".*

The above infers that features including (but not limited to): narrow pedestrian sidewalks and road lanes, pedestrian safety and the presence of parked vehicles along a road and characteristics common to the study area's internal road network are all considered when determining the environmental capacity of a particular class of road. It is important to note, therefore, that a residential roadway can be operating in excess of its environmental capacity, while still operating within its carrying capacity.

3 SURVEY METHODOLOGY AND RESULTS

3.1 Study area

The proposed study area comprises the suburb of Walmer Estate as shown in **Figure 3.1** and is bounded by:

- Nelson Mandela Boulevard to the north.
- Roodebloem Road and Upper Roodebloem Road to the east.
- De Waal Drive to the south.
- Hill Street and Searle Street to the west.

For the purposes of this study, only vehicles entering Walmer Estate via Keizersgracht/Searle Street were considered. This represents the main thoroughfare and although it is unlikely that vehicles will travel up through Walmer Estate from south of Nelson Mandela Boulevard; it is expected that if they do, they will make use of the peripheral roads (e.g. Upper Mountain Road, Rhodes Avenue and Upper Roodebloem Road) and not roads internal to Walmer Estate. This will therefore have a less pronounced impact on the community, although an opportunity exists to undertake an additional study in this regard.

Figure 3.1: Extent of Study Area and Major Rat-run Routes

3.2 Survey methodology

In order to quantify the number of vehicles rat-running on various routes through Walmer Estate, a particular type of survey had to be undertaken that made the identification of individual vehicles entering the study area and exiting the study area (at selected locations) possible. For this reason, a specific type of vehicle survey was developed that relied on the positioning of survey points on the main rat-running routes and it was, therefore, necessary to identify these routes prior to scheduling the surveys.

3.2.1 Identified rat-run routes for survey

Through site observations and discussions with City officials (who were familiar with the area), the following routes were identified as the main rat-runs to be included in the survey as shown in **Figure 3.1** and described below:

- Chester Road → Coronation Road → Nelson Mandela Boulevard (pink).
- Chester Road → Coronation Road → Nelson Mandela Boulevard (green).
- Chester Road → Coronation Road → De Waal Drive (orange).
- Hill Road → Upper Cambridge Road → De Waal Drive (blue).

It is important to note that the City rolled out the MyCiTi 102 Route (Salt River Rail – Walmer Estate – CBD) service approximately one year after the surveys were undertaken. Although this is not expected to have a significant effect on the volume of vehicles performing the rat-runs (as corroborated by members of the community in **Chapter 2.4.3**), the implementation of the service has resulted in Chester Road becoming a one-way roadway in the western direction, with Coronation Road becoming a one-way in the eastern direction, creating a couplet. As such, Chester Road no longer forms part of a rat-run route. Motorists making use of Chester Road to perform their rat-run were, therefore, assumed to divert onto Coronation Road and to a lesser extent, Eden Road, instead of redistributing to other parts of the immediate road network. This is not expected to affect the overall outcome of the study, as the exit point for these rat-runners (i.e. the destination) remains the same.

3.2.2 Methodology and survey location

As previously established, a special type of survey needed to be developed that would enable the accurate identification and tracking of individual vehicles making use of one of the four above-mentioned rat-runs. An identifier unique to each vehicle was required, with a vehicle's licence plate number selected for this purpose. Surveyors were therefore required

to record the licence plate number of each vehicle passing their survey station during the survey period.

Five survey stations were set up at various locations along the four routes within the study area as shown in **Figure 3.2** and summarised below:

- Station 1: Recorded all vehicles travelling eastbound on Chester Road.
- Station 2: Recorded all vehicles travelling southbound on Cambridge Road.
- Station 3: Recorded all vehicles accessing De Waal Drive via Upper Roodebloem Road.
- Station 4: Recorded all vehicles accessing Nelson Mandela Boulevard via Melbourne Road.
- Station 5: Recorded all vehicles accessing Nelson Mandela Boulevard via Roodebloem Road.

In addition, an intersection survey was scheduled for the Keizersgracht/Searle Street intersection in an attempt to quantify the total number of vehicles entering Walmer Estate.

The surveys were scheduled for Thursday, 28 July 2011 and Thursday, 15 September 2011 during the PM peak period, between 16:00 and 18:00 with vehicle licence plate details recorded at 5 minute intervals and for the duration of the survey while vehicle volumes at the surveyed intersection were recorded at 15 minute intervals.

Figure 3.2: Survey Station Locations

3.3 Survey results

3.3.1 Data capturing

The data obtained from the surveys was captured onto separate spreadsheets, each representing a different survey station. The licence plate data from Stations 1 and 2 was compared to the survey data from Stations 3, 4 and 5 to detect unique licence plate number matches. The presence of a unique match indicated that the identified vehicle had essentially followed one of the four rat-running routes previously identified in **Figure 3.1** e.g. a licence plate number initially recorded at Station 1 and recorded later at Station 3 indicates that the vehicle seemingly followed the Chester Road → Coronation Road → De Waal Drive route.

The capturing of the intersection count data was a straightforward exercise.

3.3.2 Interpretation of survey results

The results of the surveys are summarised in **Figure 3.3** with the two-hour intersection survey results summarised in **Figure 3.4**.

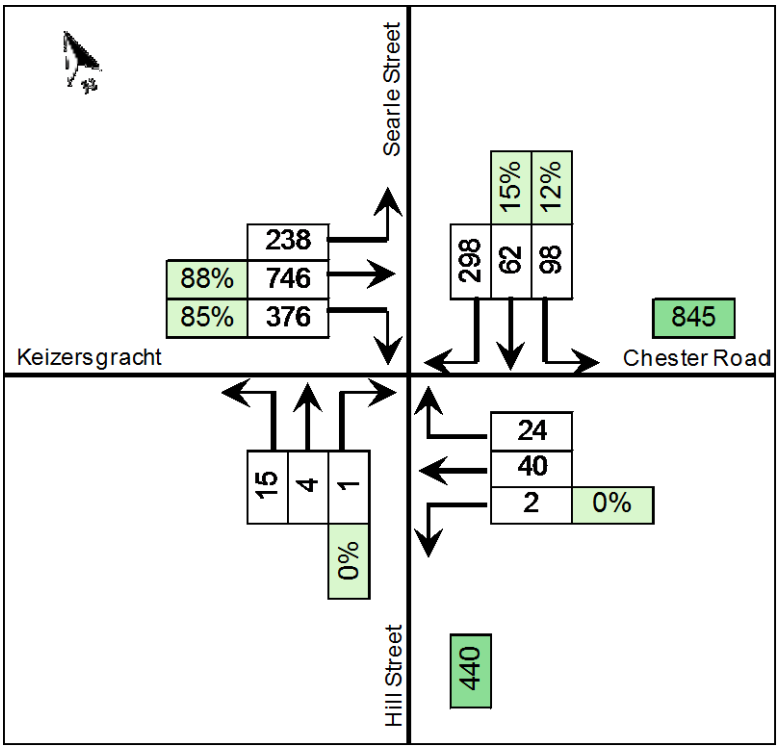

Figure 3.4: Two Hour Intersection Survey Results

Route name	Peak hour volumes (veh/hr)	2-hour vehicle volumes (veh)
Upper Cambridge	134	266
Chester / Coronation (via Roodebloem)	119	208
Chester / Coronation (via Melbourne)	140	199
Chester / Coronation / Upper Roodebloem	39	70
Total	**429**	**743**

Figure 3.3: Survey Results

Rat-runner volumes

The intersection survey results show that a significant number of vehicles making use of the Keizersgracht/Searle Street intersection during the PM peak hours travel in the direction of the study area; more than 1 900 vehicles make use of this intersection during this period and of this total, over two-thirds were recorded travelling in the direction of the Walmer Estate. The intersection survey volumes also show that the majority of vehicles entering Walmer Estate do so via the Keizersgracht approach; of the approximately 1 300 vehicles entering Walmer Estate from either the Keizersgracht or Searle Street approaches, almost 90% do so via the Keizersgracht approach.

Furthermore, two-thirds of rat-runners from the Keizersgracht approach make use of the Chester Road route (as opposed to Hill Street) and this is similar for the Chester Road approach, indicating that the Chester Road route is more popular. One reason for this is that it provides rat-runners with more exit alternatives; those making use of the Hill Street route will most likely only exit via the De Waal Drive onramp, while those making use of the Chester Road route have two onramp exit options onto Nelson Mandela Boulevard, one onramp exit option onto De Waal Drive and also have the opportunity to exit onto either Melbourne Street or Roodebloem Road and proceed towards Victoria Road (the latter two options are not included in this study).

Rat-run route-specific volumes

A comparison of the total number of vehicles entering the study area during the two hour survey period and those passing one of the three exit points (i.e. De Waal Drive, Nelson Mandela Boulevard x 2) shows that approximately 60% of all vehicles entering Walmer Estate at this intersection exit via one of the three onramps surveyed. It should be noted that, although it is not known how many vehicles entered Walmer Estate and exited via either the Roodebloem Road or Melbourne Street (to Victoria Road) exits, it can be assumed that as many as 20% to 30% made use of these routes (i.e. only 10% of vehicles entering Walmer Estate during the survey were residents), since a significant proportion of vehicles were recorded entering the study area on Chester Road (and this is the quickest route to these exits).

The results show that the Upper Cambridge route is the most popular over the two hours of the survey, but interestingly, the Chester Road/Coronation Road route was the most popular during the peak hour. This could infer that the De Waal Drive onramp reliably offers the rat-runners less delay over the two hour period i.e. a shorter travel time (since all three exits lead to the same destination) and it is therefore more attractive to the rat-runners than the other two onramps, an assumption which could be corroborated with the fact that

336 vehicles were recorded making use of the De Waal Drive onramp during the survey period compared with 199 vehicles and 208 vehicles for the other two onramps (i.e. 50% more).

The preference for using the De Waal Drive onramp could further be explained by the fact that many motorists travelling from south of Nelson Mandela Drive i.e. Woodstock and Upper Woodstock also make use of the Roodebloem Road and Melbourne Street onramps and vehicles rat-running through Walmer Estate towards these onramps are effectively competing for capacity (whereas this is not the case with the De Waal Drive onramp).

Carrying capacity of the internal road network

In terms of Transport for Cape Town's *Public Right of Way: Road Network* map (August 2013), the study area's internal road network comprises entirely of class 5 residential access roads. Furthermore, the Department of Transport's *Geometric Guidelines of Urban Local Residential Streets* (Draft UTG7, 1988) recommends for this class of road (i.e. class 5) a peak hour volume of less than 200 vehicles is desirable (i.e. the environmental capacity) and this is also in line with Committee of Transport Officials' *South African Traffic Impact and Site Traffic Assessment Standards and Requirements Manual* (December 2010) recommended threshold value (i.e. less than 200 vehicles per hour).

It should be noted, that this threshold value should be considered the "maximum" i.e. for a typical class 5 road, with a typical cross-section and under average conditions. It can, therefore, be argued that the environmental capacity of the roads within the study area is less than 200 vehicles per hour, due to inter alia: the high prevalence of on-street parking as a result of limited driveway accesses (i.e. off-street parking) and narrow road widths that are a typical feature of a heritage area. For simplicity's sake, the threshold of 200 vehicles per hour will be used.

The results of the intersection survey show that almost 450 vehicles and 850 vehicles make use of Hill Street and Chester Road respectively during the two hour survey period. With the above recommended environmental capacity threshold in mind, it is possible to conclude that these roads are currently operating in excess of their environmental capacity (i.e. roads are carrying more traffic than what is fit for purpose). Furthermore, since a significant proportion of these vehicles are rat-runners it stands to reason that this continuing daily PM peak period occurrence has become a serious problem for the community and has resulted in City officials actively engaging with the community over a prolonged period in an attempt to solve this problem.

Ultimately, it seems reasonable to conclude that these rat-runners are solely responsible for certain residential access roads located within the study area operating in excess of their environmental capacity.

4 PROPOSED MITIGATING MEASURES

It is a serious concern for both the City and the affected community that certain roads within the study area are operating in excess of their environmental capacity as a consequence of weekday PM peak rat-running. For the City, these concerns are related to: unplanned maintenance and infrastructure expenditure associated with the resulting road (surface) deterioration and possible political consequences due to a perceived “lack of action” by the affected community (and greater population). For the affected community, these concerns relate to having to cope with the short-, medium- and long-term health and safety consequences of the excessive daily vehicle volumes.

It is important for all involved that effective mitigating measures (i.e. able to affect a decrease in rat-running volumes) are implemented within the study area. The purpose of this chapter is therefore to make use of what has been revealed in the previous chapter regarding the travel patterns, preferred routes and overall volume of rat-runners moving through the study area, in combination with the information presented in **Chapter 2**, to identify potentially effective mitigating measures and develop a long-term solution to this problem.

Upon considering the road network surrounding the study area, the amount of input data required and the numerous scenarios that would have to be tested as a result of the implementation of the proposed mitigating measures, it was decided that the efficacy of the proposed measures would not be tested by way of traffic modelling software. This exercise would significantly increase the scope, cost and length of the study and since limited vehicle volume data was captured during the surveys, no real value exists in producing modelled results (i.e. the model results would be meaningless). Certain assumptions that would have been used as inputs for the model can still be used in a similar fashion; since these assumptions are in effect “mini-assessments” of certain identified key factors, they will be used to undertake a pragmatic assessment of the likely effectiveness of the proposed mitigating measures. Further investigation will be undertaken for those measures deemed likely to be effective, with a multi-criteria analysis used to determine the preferred alternative.

It is acknowledged that certain mitigating measures, such as adopting a planning-based strategy, may take some time to implement and one would have to wait even longer for them to have a quantifiable mitigating impact, although the opposite is also true. As such two different types of mitigating measures will be discussed: medium-to long-term measures that would take time to implement and short-term measures that could be

implemented almost immediately (relatively). Proposals for these two different types of measures are assessed overleaf.

4.1 Medium and Medium-to Long-term Measures

The proposed redevelopment of District Six, in addition to the TOD-based planning approach undertaken by the City of Cape Town, is expected to have a significant impact (change) on travel patterns and travel behaviour for vehicles travelling on the road network surrounding the study and by extension, rat-runners currently travelling through Walmer Estate. It should be noted that these measures will take many years to implement (CTSDF is a 20 year plan) and are, therefore, classified as medium or medium-to long-term measures.

4.1.1 Redevelopment of District Six

The proposed redevelopment of District Six will, significantly, increase the existing development density (currently almost zero) of the area neighbouring Walmer Estate. This will result in an expected addition of vehicle trips to the existing and proposed road network. While these additional vehicles are not anticipated to form part of the existing rat-run through Walmer Estate during the PM peak period, these additional vehicles are expected to create sufficient friction and delay (i.e. increased localised congestion) to make the Walmer Estate rat-run less appealing.

The redevelopment also proposes to change the existing Keizersgracht cross-section through inter alia: halving the number of lanes, implementing bus-priority measures at intersections and allowing space for different modes through dedicated lanes all of which effectively decrease the carrying capacity of the roadway. More accesses (and hence, intersections) will also be added along the length of Keizersgracht to facilitate the new road network. These changes will make this route more onerous for rat runners; increasing both delay and travel-time and in so doing making this rat-run less appealing. It is anticipated that this will act as a trigger and cause a certain amount of rat-runners to change routes, somewhat increasing the capacity on the major routes by reducing the delays experienced downstream normally caused by re-entering rat-runners. Although at first it appears contradictory, this creates a causative link (to a point) between rat-runners moving to major roads and a decrease in congestion on the major roads.

There is a risk that the rat-runners will simply change to a different rat-run route (e.g. via Woodstock or Salt River, instead of changing to one of the major routes) as a result of the redevelopment; however, this is something that requires further investigation and does

change the effect that the proposed redevelopment will have on rat-runners through the study area.

4.1.2 TOD-based Planning Approach

The City's stance on TOD as the preferred long-term planning approach is expected to affect a modal shift from private car usage to public transport commuting; though it would be difficult to accurately predict the percentage shift as a variety of factors will ultimately influence the success of this approach. It should be noted, however, that this modal shift does not automatically imply a reduction to the current number of private car users; it may simply suggest that the annual growth rate for the private car mode is slower compared to that of public transport.

With the above in mind, the proposed modal shift in itself is not expected to bring about a decrease in congestion on the City's road network. As was expressed at the beginning of **Chapter 2**, creating additional capacity within a road network (in this case possibly through a modal shift) will not have a lasting effect, as traffic levels will begin to increase (unlocking the latent demand) until such time as the road network reaches "peak congestion" (as before).

The most important outcome of the successful implementation of this long-term strategy will be the positive effects that TOD will have on traveller behaviour. As detailed in **Chapter 2**, the City can expect a city-wide reduction in VKT and an associated decrease in overall congestion levels and travel times. It is anticipated that to some extent these decreases will once again make the major routes attractive to the rat-runners, luring them back from the suburban areas. Furthermore, with the City's increased focus on mixed land-use development and intensification, vehicle trip lengths are expected to decrease. People will start to live closer to work (or vice versa), which will reduce the need to rat-run.

In contrast to the proposed redevelopment of District Six, the implementation of this approach is expected to have a city-wide (positive) impact and is therefore not expected to have any adverse transport-related effects on suburbs neighbouring the study area.

4.1.3 Discussion

The combined effect of the successful implementation of the two above-mentioned medium or medium-to long-term measures is viewed as the eventual solution to the current rat-running problem investigated in this study. These measures offer a suitable assortment of "hard" and "soft" measures (e.g. physical changes to the Keizersgracht cross-section vs promoting a change in traveller behaviour), without needing to alter the study area's internal road network and is considered a holistic solution to the problem.

4.2 Short-term Measures

Given that the medium and medium-to long-term measures described in the previous section are regarded as the ultimate solution to the study area's rat-running problem, it becomes necessary to implement an interim (or short-term) solution that is able to significantly mitigate the existing rat-running problem. A considerable amount of information has been presented in the literature review section and it is proposed that this information, in conjunction with what has been learnt from the survey results, is used to determine the short-term mitigating measures that are most likely to be effective.

As it would be too laborious to test the efficacy of every possible mitigating measure, the manner of identifying possible solutions will follow a similar method to that of a process of elimination; a number of statements, conditions and inferences will be detailed below which will form the basis of the criteria used to assess the likely efficacy of all the potential short-term mitigating measures. Those measures still deemed likely to be effective will be introduced and investigated further and a multi-criteria analysis will be used to determine the preferred alternative. It should however be noted that the actual (i.e. quantifiable) traffic-related impact that the preferred alternative will have on the surrounding road network will have to be analysed (modelled) in a separate study. The following information was therefore considered when determining the likely efficacy of the proposed measures (presented in no particular order):

- All previous proposals that were presented to the affected community (as part of the City's prolonged public participation process) in search of a solution to this problem and were discarded during the process will not be considered as viable solutions to the problem.
- The mitigating measures that were eventually chosen and implemented by the City in 2014 as part of a prolonged public participation process proved to be unsuccessful. This could either mean that the implementation of "soft policy" measures such as educating rat-runners and the use of signage to prevent rat-runners is ineffective, or that these measures can only be effective with the appropriate on-site traffic enforcement (or a combination of both).
- The City does not currently have sufficient capacity within its traffic enforcement department to undertake daily on-site enforcement within the study area and, therefore, any mitigating measures that rely solely on this type of enforcement as the over-arching mechanism for success will not be considered.
- A total of 16 traffic calming measures (in the form of vertical deflectors) have been constructed at various locations on the main rat-running routes within the study area

over the course of the past five to ten years. Based on community feedback regarding the current situation and the results of the OD surveys, these measures seem to have little effect in reducing the overall number of rat-runners moving through the study area. As such, it is concluded that the implementation of additional traffic calming measures (in the form of vertical deflectors) is not a viable short-term solution to this problem.

- MyCiTi bus routes currently operate on Chester Road, Coronation Road and sections of: Upper Mountain Road, Rhodes Avenue and Upper Roodebloem Road. The preferred alternative would have to retain the integrity of these public transport routes and should not significantly affect the travel time or ride quality of the services operating on these routes.
- As this is viewed as an interim solution, the costs associated with the design, implementation and ongoing monitoring of the preferred alternative should not be excessive or prohibitive.
- It is assumed that the majority of Walmer Estate residents would be focussed on accessing the study area during the PM peak period, with very few expected to attempt to exit onto the main roads during this period. The focus should therefore be on preventing rat-runners from accessing the onramps, allowing the residents unimpeded access into the study area.
- Decreasing the amount of rat-runners travelling through Walmer Estate by limiting access at the onramps to the major routes is expected to increase capacity on the major roads, by reducing the delays (and shock waves) caused by vehicles rejoining these roads. As such, it is argued that the rat-runners would naturally drift back to these major routes due to the associated decreased congestion and travel times.
- All three of the surveyed rat-runs routes are well used during the PM peak period and to prevent the subsequent redistribution of traffic to the other “available” (untreated) rat-run routes within the area, the preferred alternative should be able to be implemented so as to affect all four routes to ensure success.
- Where possible, the preferred alternative should not impede the movement and access of emergency vehicles.
- The preferred alternative should be deemed appropriate and acceptable by the community.
- The preferred alternative should not have a negative effect on road safety within the study area.
- The road network comprising the study area does not lend itself to the further conversion of two-way roads into one-way couplets.
- The narrow road widths (and road reserves) that are a characteristic of the study area makes it difficult to construct certain physical measures (e.g. chicanes).

- The preferred alternative should allow for the high incidences of on-street parking observed throughout the study area.
- As this is a short-term solution, the preferred alternative should be able to be implemented within a relatively short time-frame (i.e. months instead of years).
- If possible, the preferred alternative should only be operational during the PM peak period, as this will result in minimal disruption to traffic flows outside of this period.

Using the above information as a basis for excluding a number of potential measures, three alternatives were considered as potentially viable short-term solutions for further investigation and are described in **Chapters 4.2.1** to **4.2.3**.

4.2.1 Alternative 1: Barriers (Horizontal Deflections)

The construction of barriers (i.e. horizontal deflection measures) at key locations to prevent rat-running vehicles from performing the requisite turning movements (to complete their rat-run route) was identified as a potentially viable solution (i.e. "Alternative 1") for further interrogation. The proposed placement of these measures is shown in **Figure 4.1**.

Half-lane Closure on Melbourne Street Bridge (northbound)

This measure will prevent access to Upper Woodstock for vehicles from Walmer Estate and in so doing, stops rat-runners from rejoining Nelson Mandela Boulevard.

Construction of Left-only Turning Lane on Western Approach to Roodebloem Road Intersection

This measure prohibits vehicles at the western approach of the Roodebloem Road intersection from turning right and, therefore, prevents rat-runners from rejoining Nelson Mandela Boulevard.

Construction of Left-only Turning Lane on Western Approach to Rhodes Avenue / Upper Roodebloem Road Intersection

This measure prevents vehicles at the Rhodes Avenue approach from turning right onto Upper Roodebloem Road, thereby effectively preventing rat-runners from rejoining De Waal Drive. Furthermore, the measure will retain the access functionality required for the MyCiTi services making use of this intersection.

Figure 4.1: Proposed Locations of Barriers for Alternative 1

Construction of a Median Island at the Westford Road / Upper Roodebloem Road Intersection

The construction of this measure prevents vehicles at the Westford Road approach from turning right onto Upper Roodebloem Road, thereby effectively preventing rat-runners from joining De Waal Drive.

Construction of a Median Island between the Ritchie Street / Roodebloem Road and Selbourne Road / Roodebloem Road Intersections

The construction of this measure prevents rat-running vehicles originating from Rhodes Avenue from turning left into Roodebloem Road, diverting right into University Estate via Ritchie Street and re-entering (Upper)Roodebloem Road travelling southbound.

Discussion

One of the benefits associated with this solution is that it allows residents unrestricted access into the study area during the PM peak period, while blocking rat-running routes by physically banning the necessary vehicle movements. Furthermore, the cost and lead time associated with the design and implementation of these measures is not considered excessive and allows for access functionality required for the MyCiTi services operating within this area to be retained.

There are, however, disadvantages associated with the implementation of these measures including (but not limited to): limited access to the external road network for residents which could lead to unrest, hotel guests leaving to go to the airport (i.e. eastbound on the N2) will find the new diverted route cumbersome, the measures are permanent, rat-runners may start performing dangerous and illegal U-turn movements in an attempt to bypass the measures and there is also the potential that these measures actively divert traffic into University Estate or the Upper Woodstock area, compounding traffic problems in that area. In addition, these measures will have a permanent effect on travel patterns (i.e. cause a redistribution of traffic) which is not preferred.

4.2.2 Alternative 2: Suburb-wide Woonerf Treatments

The second potentially viable alternative would be to undertake a suburb-wide (i.e. the study area) approach and develop and implement woonerf-style treatments for particular roads within Walmer Estate (“Alternative 2”). It is anticipated that these measures will make existing rat-run routes significantly more onerous, which is associated with a negative experience for rat-runners. It is likely that these measures will therefore cause a decrease in rat-running volumes within the study area. In addition, these measures will improve the quality of life for residents of the area, not only through the reduction in rat-runners, but also

through the provision of safe spaces for the community to interact on, allowing ample space for on-street parking.

It should be noted that although these measures will make travelling through Walmer Estate more onerous for residents too, it is expected that the perceived benefits will negate this. There are, however, certain drawbacks associated with these measures; there are concerns regarding the length of time required to implement these measures as a lengthy study to identify locations for these measures and numerous design options would have to be prepared prior to implementation (in addition to the time take to construct these measures), these measures also do not have a particularly positive effect on the surrounding road network as access to the major routes is not restricted at all and rat-running traffic may simply divert to a neighbouring suburb. Furthermore, the associated costs could be prohibitive (certainly more expensive than Alternative 1) and the required consideration for public transport and emergency services vehicles operating within the area may influence the overall efficacy of the proposed treatment.

4.2.3 Alternative 3: Ramp-metering

The third and final alternative for investigation is the implementation of ramp-meter signals at key locations ("Alternative 3"), with the approximate location of the signal heads shown in **Figure 4.2** and described below.

Melbourne Street On-ramp to Nelson Mandela Boulevard

The implementation of a ramp-meter signalling system at this location will manage the number of vehicles allowed to rejoin Nelson Mandela Boulevard and will also control the amount of vehicles rat-running on Melbourne Road via Walmer Estate. If desired, the location of the system can be moved further south, closer to the on-ramp.

Western Approach to Rhodes Avenue / Upper Roodebloem Road Intersection

The implementation of a ramp-meter signalling system at this location will manage the number of vehicles allowed to rejoin Nelson Mandela Boulevard and will also control the amount of vehicles rat-running on Roodebloem Road via Walmer Estate.

Upper Roodebloem Road On-ramp to De Waal Drive

The implementation of a ramp-meter signalling system at this location will manage the number of vehicles allowed to rejoin De Waal Drive.


N
Melbourne Street
Coronation Road
Chester Road
Roodebloem Road
Nelson Mandela Boulevard
Rhodes Avenue
Upper Roodebloem Road
Westfort Road

Discussion

A key feature of this alternative is the fact that the ramp-meter signals only activate when a predetermined vehicle volume threshold value is exceeded on the major road. Once the induction loops, placed on either side of the onramp access, detect that this value has been exceeded, the system becomes operational. The signals then allow only between one and three vehicles to enter the system at a time, with this "cycle time" calculated based on a variety of factors.

This allows the onramps to function as normal outside of these specific periods and as such, will have no impact on the road network during these periods (as the signals aren't activate). It should be noted that this benefit is only afforded by this alternative, as Alternatives 1 and 2 will have a permanent effect on the road network and traffic flow; resulting in a potential redistribution of traffic.

Furthermore, the implementation of these measures makes it possible to restrict access to all five of the major rat-run routes (even though only three were surveyed as part of this study), depending on the positioning of the signals at the Melbourne Street and Roodebloem Street onramps. This type of total restriction is something not offered by Alternatives 1 and 2**.** The increase in delay experienced by rat-runners at these onramps, as a result of the implementation of the signals, is expected to cause rat-runners to switch to a totally different route and, possibly, back to the main routes (due to the decrease in delay associated with the restriction of access). In addition, these measures allow residents unimpeded access to the study area during the PM peak hour, only restricting access out of the study area at accesses onto the external road network (although this is not expected to significantly affect residents).

There is a possibility of the rat-runners not adhering to the signals (i.e. "jumping the red light"), however this can easily be mitigated through the introduction of a traffic camera that will take photos of transgressors, allowing for fines to be issued. Active enforcement by officers is therefore not required. There is also a concern that public transport and emergency services may be affected, however this can be mitigated by the construction of bus queue jumps in the vicinity of the approaches, which allows for buses (or emergency vehicles) to move to the front of the queue.

The cost associated with the implementation of these measures is not expected to be prohibitive (i.e. cheaper than Alternative 2 but more expensive than Alternative 1) and the lead time for implementation is considered reasonable.

4.2.4 Selection of the preferred alternative

A weighted multi-criteria analysis (MCA) was used to assess the three alternatives to determine the preferred alternative. It should be noted that while there was every intention to utilise real data from previous literature (case studies) to compare and assess the efficacy of the proposed alternatives, a review of the available data revealed that this was not possible for the following reasons:

- Although the literature provided real data values for certain criteria (e.g. the percentage range reduction in traffic volumes), these criteria were not consistent for the different types of measures comprising the three alternatives, making it impossible to compare alternatives.
- Almost all of the literature results pertain to international studies, where traffic conditions, driver behaviour and driver compliance are not specifically relatable to the South African context. It is acknowledged that the results of these studies can provide general insight into the efficacy of the three alternatives; however, due to the sensitivities involved in the analysis of the alternatives, using marginally incorrect data could lead to inaccurate analysis results.
- The literature generally provides results based on assessments of a group of homogeneous measures. Since the study area has already been calmed by way of vertical deflection measures, the cumulative effect of combining different types of measures (i.e. alternative plus the existing calming) cannot be accurately predicted.
- The context of the studies undertaken in the literature differ to that of this case study and the published results are therefore not directly comparable or relatable.

The purpose of the initial “screening” process described in **Chapter 4.2** was to identify (with certainty) a number of measures that could reduce the number of rat-runners moving through the study area and, as such, all three of the alternatives can be assumed to be generally effective in reducing the number of vehicles rat-running through the study area. Real data has been used in the analysis where possible, although a more practical approach has had to have been undertaken when assessing and comparing the alternatives for the MCA. As per the failings of the City’s previously approved measures for the study area, there is perhaps added value in assessing criteria that will ensure overall efficacy, as opposed to assessing criteria that merely quantify the efficacy of a measure by detailing certain traffic-flow related indicators. This ensures an overall holistic assessment of the measures.

The “true” (i.e. quantifiable) effectiveness of each alternative would be difficult to quantify without undertaking a modelling simulation. The purpose of the MCA is, therefore, to

consider all of the aspects that would play a role in the overall efficacy of the measures, in order to identify the preferred alternative for further investigation by way of modelling.

It should be noted that a number of traffic calming measures have already been installed at various locations within the study area, which would account for an overall reduction in the travel speeds of vehicles moving through Walmer Estate. While a further reduction in travel speed may mitigate the effects of rat-running by increasing travel time, this is not expected to have a significant effect on the overall safety of residents and as such, safety has not been considered as a criterion for assessment.

The criteria used in the scorecard were mainly derived from the various factors presented at the beginning of this section and are discussed below.

Cost

This criterion is related to the cost of implementation of each alternative. It is acknowledged that the overall cost of a measure does not determine its efficacy; however, due to the current economic climate, City budgets, project priority, etc it becomes necessary to consider cost. It is important to remember that if the most expensive solution is indeed the most effective, this will be reflected in the results, since the alternatives will be ranked using a MCA (i.e. cost only contributes a portion of the overall analysis criteria).

Enforcement

The literature review section describes how the previously-approved rat-run mitigating measures failed as they were heavily reliant on enforcement to ensure efficacy. The preferred alternative should, therefore, not rely on outside enforcement having to be provided by the City's Traffic Services department and should be able to reasonably ensure compliance (i.e. self-governing/self-regulating). A negative score will be attributed to alternatives that require traffic enforcement or cannot reasonably ensure compliance.

Accessibility

One of the problems related to the various rat-run mitigating measures that were originally proposed by City officials (to Walmer Estate residents) was related to access. Residents stated that they required unimpeded access into the area during the PM peak period and the preferred alternative should be able to satisfy this requirement. In addition to this requirement, unrestricted access to the external road network (major roads) following the implementation of the preferred alternative is viewed as an additional benefit to the residents. It is detrimental to permanently block off accesses for all vehicles at all times of

the day, when rat-runners (during the weekday PM peak period) are the actual focus of this study.

Maximum Diversion Length

In addition to accessibility, the maximum diversion length for alternatives will also be assessed. This criterion is only applicable to Walmer Estate residents, and reflects the maximum additional distance (when compared to the existing scenario) that residents would have to travel in order to gain access to the external road network from any point within the study area.

Effect on Surrounding Road Network

The goal of the mitigating measures is to successfully reduce the number of vehicles currently rat-running through Walmer Estate during the weekday PM peak period; however, it is also important to consider the overall effect that that these alternatives will have on the surrounding road network. The purpose of including this criterion in the MCA is to penalise alternatives that only achieve this by actively diverting rat-runners to a neighbouring area and to reward alternatives that will have a positive effect on the surrounding road network.

Implementation Time

The preferred alternative is viewed as a short-term solution and the time taken to implement should be apt.

A summary of the criteria, unit of measurement, adjusted score, etc. for each alternative is summarised in **Table 4.1**.

Table 4.1: Criteria Summary of the Three Alternatives

Criterion	How Measured	Unit of Measurement	Base Values			Adjusted Values		
			Alternative			Alternative		
			1	2	3	1	2	3
Cost*	Overall cost of implementation (including design fees, etc.)	ZAR	R 3 million	R 7.5 million	R 6 million	1,0	0,4	0,5
Enforcement	Minimum number of traffic officers required for enforcement.	number of officers	1	0	0	0	1	1
Accessibility	Number of accesses available to the external road network.	number of accesses	1	5	5	0,2	1	1
Maximum Diversion Length	Maximum additional distance required to be travelled by residents wanting to access the external road network.	meters	500m	0	0	0,5	1	1
Effect on Surrounding Road Network	Overall positive or negative effect.	+ve or -ve score	-ve	neutral	+ve	-1	0	1
Implementation Time	The amount of time taken from project inception to implementation.	number of years	0.5 years	2 years	1 year	1	0,25	0,5

* Costs associated with the implementation of these measures were determined through discussions with consulting engineers. It should be noted that although these costs are high level estimates, the overall relationship between the three are expected to be consistent.

A specific weighting (expressed as a percentage) was given to each criterion based on its perceived importance to the overall efficacy of the measure – for example the highest weighting was assigned to a measure that could be implemented in a short space of time, whereas lower weightings were given to criteria that weren't as vital to the efficacy of a measure (i.e. "nice to haves").

The alternative achieving the highest score would therefore represent the preferred alternative. The result of the multi-criteria analysis undertaken for the three alternatives is shown in **Table 4.2**.

Table 4.2: Multi-criteria Analysis – Selection of Preferred Alternative

Criterion	Weighting (Importance)	Alternative		
		1	2	3
Cost	0,1	1	0,4	0,5
Enforcement	0,25	0	1	1
Accessibility	0,25	0,2	1	1
Maximum Diversion Length	0,05	0,5	1	1
Effect on Surrounding Road Network	0,05	-1	0	1
Implementation Time	0,3	1	0,25	0,5
	TOTAL	0,425	0,665	**0,8**

The above table shows that Alternative 3 scored the highest in the multi-criteria analysis and is thus identified as the preferred alternative. It is therefore recommended that further investigations in the form of modelling simulations, etc are undertaken to properly document the traffic impacts resulting from the implementation of this measure. Although this study has revealed Alternative 3 to be the most likely effective solution, a final decision regarding the implementation of this alternative can only be made once the results of the additional studies have been presented.

5 CONCLUSIONS AND THE WAY FORWARD

5.1 Conclusions

Traffic congestion is common throughout the world and occurs in both developed and developing countries. As a result of these congestion problems and ever-increasing travel times certain motorists, in an attempt to reduce travel times, will perform rat-runs which involve making use of secondary roads or residential side streets instead of major roads in an attempt to avoid or bypass congestion. This practice has a significant negative effect on the communities through which the rat-run is performed, leading to a variety of safety, health, economic, etc problems. This is particularly evident in Walmer Estate, Cape Town, where the impact of poor legacy planning within the City and sub-standard public transport provision has resulted in many motorists rat-running through this area during the weekday PM peak period. There is no simple short-term solution to solve this problem, as the addition of extra capacity to the road network through the construction of roads merely unlocks a latent demand and adds more vehicles to the network until such time that the network is congested again.

The objective of this dissertation was to quantify what is currently happening in Walmer Estate as a result of rat-running during the PM peak period and to investigate what can be done to mitigate this practice. Several questions were asked and investigated. This chapter provides a summary of the findings with regard to each question.

Why do motorists rat-run?

Generally, the goal of any motorist travelling from an origin to a destination is to do so in the shortest possible time (within reason). Rising levels of vehicle ownership and poor land use planning has lead to many major routes (e.g. freeways, highways, arterials, etc) becoming congested during peak periods, causing excessive delays and increased travel time. Since adding additional capacity to the road network through the construction of new roads/lanes does not necessarily ease congestion levels, motorists are forced to seek out alternative ways to reduce their travel time. Once such alternative is rat-running, which involves making use of secondary or residential roads instead of major routes, in an attempt to bypass congestion. Although these “minor” roads have been designed to perform an access function and would therefore be slower to use (as opposed to major routes), during peak times they are viewed as a better alternative as they offer a reduction in travel time (albeit in some cases the route may be longer or less direct).

What decisions are made prior to a driver selecting a route?

Assuming that the driver has already decided on the destination, drivers will use all the information available to them regarding the different route choices to decide on the route that offers them the maximum utility, with various levels of emphasis placed on the disbenefits associated with the route depending on the type of driver.

What effect does land use planning have on travel behaviour, with specific reference to rat-running?

Land use planning has a significant effect on travel behaviour as it, in essence, determines the traffic flow patterns on a typical road network (i.e. the location of the origins and destinations). If urban sprawl is characteristic of the historic land use planning policies, as is the case in Cape Town, then increased driving distances and congestion can be expected. This infers an increase in travel times which results in motorists attempting to shorten their travel times through various means like rat-running.

It should be noted, however, that the converse is also true. Effective planning, such as the implementation of a City-wide TOD approach, can have a positive effect on traveller behaviour. Although localised congestion may increase as a result of this approach, motorists will undertake shorter and less frequent trips, decreasing travel times and negating the need to rat-run. In addition, proximity to public transport services may bring about a reduction in private car usage, further impacting congestion levels.

Can rat-running be mitigated? What types of measures are typically used to deter this practice?

Rat-running can, generally, be mitigated although this is dependent on the surrounding road network, internal road network and land use planning associated with the affected area. There are two types of measures that are typically used: so-called “hard policy” measures such as changes to infrastructure and “soft policy” measures, that comprise measures such as information campaigns to change driver behaviour.

In addition to these two types of measures that are typically used, there are other measures that can be used to deter rat-runners and these include: complete woonerf treatment of the affected area, the use of TDM measures, road signage and ramp metering. Each of these measures has been shown to effectively deter rat-runners.

It is, however, important to realise that although public participation from the affected community is required, it is impossible to select a universally accepted solution. Furthermore, since each scenario is unique, it is important to realise that there is not only one universal mitigating solution that must be used to deter rat-runners and each available alternative should be assessed on its merits, as it applies to the affected area to determine the most effective solution.

Is technology influencing rat-running behaviour?

With the advent of smart-phones and mobile technology, new phone-based applications have been developed that make use of the GPS functionality contained within these devices to pinpoint a user's location on the existing road network while logging their travel time; with users also given the opportunity to log incidents such as traffic collisions. This data is collected in real-time to provide an output, navigating users of this service onto routes that at that specific moment in time reflect the shortest travel time between their origin and pre-selected destination.

It is logical to infer that the application calculates the optimal route (i.e. the route with the shortest travel time) by making use of all roads comprising the road network. As such, residential roads are now being used by "outsiders" during peak periods in an attempt to avoid congestion, i.e. rat-running.

It is important to note that while certain measures can be implemented to make certain rat running routes more onerous for regular users; new technology is now actively promoting the existence of these routes to an entirely new group of potential users. This may actually lead to a greater increase in through-traffic volumes, regardless of mitigating measures that may have been installed to deter rat-runners; until such time as "true" equilibrium is reached across the road network (i.e. travel time on all routes is the same).

What is the city's medium-to-long term planning approach and how will this affect travel behaviour, particularly in the vicinity of the study area?

TCT is intent on pursuing TOD as the preferred land use strategy for the City's long-term future and as such, has developed the IPTN based on this approach. Although the majority of literature regarding the benefits of TOD have been developed from the North American context, it is reasonable to assume that most of these findings should hold true in most contexts. It is, therefore, realistic to assume a shift in modal split; towards a greater public transport and non-motorised transport share.

In addition, although one could expect an increase in the number of vehicle trips, these would be confined to a local area, characterised by high density mixed land use, with a decrease in the amount of vehicle kilometres travelled expected. This will result in less congested conditions on freeways, highways and certain arterial roads and it could be argued that these conditions will make rat-running less appealing and we can expect a gradual reduction in rat-running traffic over time as the land use strategy as rolled out.

Are there any future plans for the redevelopment of District Six and if there are, how will this affect the current traffic situation (in relation to the study area)?

The District Six area has been identified in both the CTSDF and Table Bay District Plan as an area for future medium-to high density mixed land use development, providing an additional 4 500 to 5 000 residential units. A hierarchical road network for the District Six area is proposed, with Keizersgracht identified as the activity spine of the entire development, defined by narrow road lane widths and an accompanying mix of travel modes with a focus on public transport.

The proposed development of District Six is expected to have a significant effect on traffic flow on the surrounding road network as the area is currently (mostly) undeveloped and any development that takes place will therefore add vehicles and in most cases additional components (accesses and roads) to the road network.

In the case of the ultimate development scenario one would expect an increase in localised congestion within the development. These local traffic conditions, combined with the cross-section proposed for Keizersgracht is expected to significantly reduce the number of rat-runners making use of the existing rat-run route through Walmer Estate via Keizersgracht as a result of increased travel time, increase effort, etc.

What are the main rat-running routes through the study area and how many vehicles make use of these routes during the weekday PM peak period?

There are four main routes that were identified as the main rat-running routes through the study area, prior to scheduling the surveys:

- Chester Road → Coronation Road → Nelson Mandela Boulevard.
- Chester Road → Coronation Road → Nelson Mandela Boulevard.
- Chester Road → Coronation Road → De Waal Drive.
- Hill Road → Upper Cambridge Road → De Waal Drive.

All four of the above routes are accessed by rat-runners via the Keizersgracht/Searle Street (four-way) stop-controlled intersection. The intersection survey volumes show that the majority of vehicles entering Walmer Estate do so via the Keizersgracht approach; of the approximately 1 300 vehicles entering Walmer Estate from either the Keizersgracht or Searle Street approaches, almost 90% do so via the Keizersgracht approach.

Of the four rat-run routes surveyed, the Upper Cambridge Road route was shown to be the most popular and was used by 266 vehicles during the 2-hour peak period and 134 vehicles during the peak hour. The least popular of the four routes surveyed was the Coronation Road – Upper Roodebloem Road route that was only used by 70 vehicles during the 2-hour peak period and 39 vehicles during the peak hour. Overall, approximately 750 vehicles were recorded using one of these four routes during the 2-hour peak period and 429 vehicles during the peak hour.

This represents a significant amount of additional traffic that is added to the study area's internal road network that is not associated with the residents and ultimately, these rat-runners are, therefore, solely responsible for certain roads of the study area's internal road network operating in excess of their environmental capacity during the weekday PM peak period.

What mitigating measures can be implemented within the study area to successfully mitigate the rat-running volumes and how will the efficacy of these measures be quantified?

Certain mitigating measures, such as adopting a planning-based strategy, may take some time to implement and one would have to wait even longer for them to have a quantifiable mitigating impact, although the opposite is also true. As such two different types of mitigating measures have been selected to form part of the overall rat-run mitigating strategy: medium-to long-term measures that would take time to implement and short-term measures that could be implemented almost immediately (relatively).

The combined effect of the successful implementation of the redevelopment of District Six and the City's TOD-based planning approach is viewed as the eventual (i.e. medium and medium-to-long-term) solution to the current rat-running problem investigated in this study. These measures offer a suitable assortment of "hard" and "soft" measures (e.g. physical changes to the Keizersgracht cross-section vs promoting a change in traveller behaviour), without needing to alter the study area's internal road network and is considered a holistic solution to the problem.

In the interim, however, a short-term solution is required for implementation until such time as the longer-term solutions are realised. Three alternative short-term solutions were identified: the construction of barriers at key locations within the study area, a study area-wide application of woonerf-style treatments, and the implementation of ramp meters at key locations.

A MCA of the three different alternatives was undertaken to determine the preferred alternative, with the analysis criteria generally comprising aspects that will ensure overall efficacy, as opposed to criteria detailing certain indicators (e.g. average delay effect, average reduction in travel speed, etc).

The results of the MCA showed the implementation of ramp meters at key locations as the preferred alternative.

What is recommended for the study area going forward?

It is recommended that additional modelling studies are undertaken to understand the overall effect that the implementation of ramp meters at the indicated locations (i.e. the preferred alternative) will have on the surrounding road network (and rat-run volumes) before making a decision regarding implementation.

It is, however, important to remember that the recommended medium and medium-to-long term-measures will remain the redevelopment on District Six and the outcome of the City's TOD-based planning approach.

5.2 The way forward

It is recommended that additional modelling studies are undertaken to understand the overall effect that the implementation of ramp meters at the indicated locations (i.e. the preferred alternative) will have on the surrounding road network (and rat-run volumes) before making a decision regarding implementation.

It is however important to remember that the recommended medium-to long term measures will remain the redevelopment on District Six and the outcome of the City's TOD-based planning approach.

6 REFERENCES

1. <http://census2011.adrianfrith.com/place/199041>. [11 December 2015].
2. *10 Million Kilometres Driven in South Africa Using Waze and Other Info from Mobile World Congress 2015*. < http://thetechieguy.com/10-million-kilometers-driven-in-south-africa-using-waze-and-other-info-from-mobile-world-congress-2015/>. [11 December 2015].
3. Appleyard D., Gerson M.S., Lintell M. 1981. *Liveable Streets*. University of California Press. Berkeley, USA.
4. Archer, et al. 2008. *The Impact of Lowered Speed Limits in Urban and Metropolitan Areas: Version 5.00*. January 2008.
5. Armstrong, A. 2014. *Only 11 Fines in Walmer Rat-Run*. <http://woodstocklife.weebly.com/news/only-11-fines-in-walmer-rat-run>. [11 December 2015].
6. Banister, D. 2012. *Assessing the reality—Transport and land use planning to achieve sustainability*. The Journal of Transport and Land Use 5(3): pp 1-14.
7. Barragan, B. 2015. *LA City Councilmember Wants to Make Waze Useless*. <http://la.curbed.com/archives/2015/04/la_city_councilmember_wants_to_make_waze_useless.php>. [11 December 2015].
8. BBC News. 2015. *Drop in Number of Traffic Police in England and Wales*. <http://www.bbc.com/news/uk-31260003>. [11 December 2015].
9. Behrens, R. 2002a: *Matching networks to needs and the configuration and management of local movement networks in South African cities*, PhD dissertation, University of Cape Town. (Chapter 4: The configuration and management of local networks)
10. Behrens, R. 2012. *Theoretical Perspectives on Modal Choice*, lecture notes distributed in END5036Z at the University of Cape Town, on 27 March 2012.
11. Bem, D. J. 1972. *Self-Perception Theory*. In L. Berkowitz (Ed.), Advances in Experimental Social Psychology Vol. 6, pp.1-62. New York: Academic Press
12. Bhatta, B. 2010. *Analysis of Urban Growth and Sprawl from Remote Sensing Data*. Berlin
13. Bruegmann, R. 2008. *Point: Accessibility and Sprawl*. The Journal of Transport and Land Use 1(1): pp 5 - 11.
14. Buchanan, C. 1963. *Traffic in Towns: A Study of the Long Term Problems of Traffic in Urban Areas (The Buchanan Report)*. Routledge.

15. Buchanan, C. 1963. *Traffic in Towns: A Study of the Long Term Problems of Traffic in Urban Areas*. Her Majesty's Stationary Office. London, England.

16. Chin, N. 2002. *Unearthing the Roots of Urban Sprawl: A Critical Analysis of Form, Function and Methodology*. University College London Centre for Advanced Spatial Analysis Working Papers Series – Paper 47. March 2002.

17. City of Cape Town. 2012. *Annual Vehicle Screenline Survey.*

18. City of Cape Town. 2012. *Cape Town Spatial Development Framework Statutory Report*.

19. City of Cape Town. 2012. *Cape Town Spatial Development Framework: Statutory Report*. May 2012.

20. City of Cape Town. 2012. *Table Bay District Plan: Spatial Development Plan and Environmental Management Framework Technical Report*. October 2012.

21. City of Cape Town. 2013. *Draft Integrated Transport Plan 2013 – 2018.* Cape Town.

22. City of Cape Town. 2013. *Milnerton South – Paarden Eiland Local Area Spatial Development Framework: Development and Implementation Framework Draft Report*. May 2013.

23. City of Cape Town. 2013. *Minimum Standards for Civil Engineering Services in Townships: Version 1*. July 2013.

24. City of Cape Town. 2014. *Integrated Public Transport Network Plan 2032: Network Plan*. May 2014.

25. City of Cape Town. 2014. *Transit-oriented Development to Determine Cape Town's Future.* Media Release, 22 October 2014. <https://www.capetown.gov.za/en/MediaReleases/Pages/TransitorienteddevelopmentdetermineCapeTownsfuture.aspx>. [11 December 2015].

26. Committee of Transport Officials. 2010. *South African Traffic Impact and Site Traffic Assessment Standards and Requirements Manual.* December 2010.

27. Crane, R. 2008. *Counterpoint: Accessibility and sprawl*. The Journal of Transport and Land Use 1(1): pp 13-19.

28. Crouse, W. 2004. *Traffic Calming: A Social Issue*. Bulletin of Science, Technology and Society, Vol. 24, No. 2: pp 138-144. April 2004.

29. CSIR. 2005. *Guidelines for Human Settlement Planning and Design*. Pretoria.

30. Department of Planning, Monitoring and Evaluation. 2014. *Medium-Term Strategic Framework* 2014 – 2019.

31. Duranton, G., Turner, M. 2011. *The Fundamental Law of Road Congestion: Evidence from U.S. Cities*. American Economic Review 101(6): pp 2616–52.

32. Festinger, L. 1957. *A Theory of Cognitive Dissonance*. Stanford, CA: Stanford University Press.

33. Garrod, G., Scarpa, R., Willis, K. 2002. *Estimating the Benefits of Traffic Calming on through Routes: A Choice Experiment Approach*. Journal of Transport Economics and Policy, Vol. 36, No. 2: pp. 211-231. May 2002.

34. Hislop, R. *Rendering the Rat-Run Unrunable*. <http://www.woodstock.org.za/rendering-the-rat-run-unrunable/>. [11 December 2015].

35. Jobanputra, R. 2012. *Quantifying the Impact of Infrastructure Based Traffic Calming on Road Safety: A Case Study in Cape Town.* 12th WCTR, July 11-15, 2010 – Lisbon, Portugal.

36. Legrain, A., Eluru, N., El-Geneidy, A. 2014. *Am Stressed, Must Travel: The Relationship Between Mode Choice and Commuting Stress*. Transportation Research Part F 34: pp 141–151

37. McCann, Barbara. 2000. *Driven to Spend*. Surface Transportation Policy Project. [11 December 2015].

38. McKee, B. 2003. *As Suburbs Grow, So Do Waistlines*, The New York Times, September 4, 2003. [11 December 2015].

39. Middelham, F., Taale, H. 2006. *Ramp Metering in the Netherlands: An Overview*. 11th IFAC Symposium on Control in Transportation Systems Delft, Netherlands, August 29-30-31, 2006.

40. MR Cagney (Pty) Ltd. 2013. *The Economic Impacts of Parking Requirements in Auckland*. 28 August 2013. Auckland.

41. National Department of Rural Development and Land Reform. 2012. *District Six Development Framework*. March 2012.

42. National Department of Transport, 2015. *National Road Traffic Act No. 93 of 1996: Publication of the National Road Traffic Regulations for Comments*. National Gazette, No. 38772 of 11 May, 2015.

43. National Department of Transport. 1988. *Geometric Guidelines of Urban Local Residential Streets – Draft UTG7*. Pretoria.

44. National Department of Transport. 2012. *South African Learner Driver Manual: Section 2*. Pretoria. June 2012.

45. Netherlands Ministry of Infrastructure and the Environment. *Residential neighbourhood gets 15 kilometres per uurbord.* <https://www.rijksoverheid.nl/actueel/nieuws/2012/04/17/woonerf-krijgt-15-km-per-uur-bord>. [11 December 2015].

46. Newman and Kentworthy. 1989. *Cities and Automobile Dependence.*

47. Nicholson, R. 2014. *Anger over Rat-Run Clampdown "No-Show".* <http://www.iol.co.za/capetimes/anger-over-rat-run-clampdown-no-show-1.1635010#.VmtXokr5iUk>. [11 December 2015].

48. O'Flaherty, C. 1996. *Transport Planning and Traffic Engineering 4th edition.*

49. Oxford Dictionaries. 2015. *Rat Running*. Available from: <http://www.oxforddictionaries.com/definition/english/rat-run> . [11 December 2015].

50. Petersen, T. 2015. *Cape Town to Spend R40million of More Traffic Officers.* <http://www.news24.com/SouthAfrica/News/Cape-Town-to-spend-R40m-on-more-traffic-officers-20150812>. [11 December 2015].

51. Statistics South Africa. 2014. *National Household Travel Survey: February to March 2013.* Statistical Release P0320. Pretoria.

52. Taniguchi, A., Grääs, C., Friman, M. 2014. *Satisfaction with Travel, Goal Achievement, and Voluntary Behavioural Change*. Transportation Research Part F 26: pp10–17.

53. Tomtom. 2014. *Tomtom South African Traffic Index*.

54. Transport for Cape Town. 2013. *Public Right of Way Road Network Map*.

55. TRB (Transport Research Board). 2002. *Transit-Oriented Development and Joint Development in the United States: A Literature Review.* Transit Cooperative Research Program Research Result Digest No. 52. Transport Research Board, Washington DC.

56. VTPI (Victoria Transport Policy Institute). 2005. *Transit Oriented Development: Using Public Transit to Create More Accessible and Liveable Neighbourhoods*. Online TDM Encyclopaedia – Transit Oriented Development. Victoria Transport Policy Institute. <http://www.vtpi.org/tdm/tdm45.htm>. [11 December 2015].

57. Wardrop, J.G, Whitehead, J.I. *Correspondence: Some Theoretical Aspects of Road Research.* ICE Proceedings: Engineering Divisions 1(5): 767.

58. Wilkinson, P. 2006. *'Transit Oriented Development': A Strategic Instrument for Spatial Restructuring and Public Transport System Enhancement in South African Cities?* Proceedings of the 25th Annual South African Transport Conference. 10 - 13 July 2006.

59. World Bank. 2015. *Motor Vehicles (per 1 000 people).* Available from: <http://web.archive.org/web/20140209114811/http://data.worldbank.org/indicator/IS.VEH.NVEH.P3>. [11 December 2015].