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Effect of land-use change on traffic peak hour factor

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DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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CERTIFICATION

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DEDICATION

This thesis is dedicated to my one year old son, Onthatile.

ABSTRACT

Growth in land development in South Africa resulted in large increase in traffic volumes. A Traffic Impact Assessment (TIA), as a traffic engineering tool, is commonly used to assess the possible effects of a land development project on the transportation and traffic system. During the TIA process, capacity analysis is performed to indicate the measures of effectiveness of the intersection. Intersection capacity analysis in South Africa by engineers is done on the basis of default values of the Peak Hour Factor (PHF) provided by the Highway Capacity Manual (HCM) or limited traffic counts. However, the default value of PHF may be significantly affected by new developments in the neighbourhood of the intersection.

This study aimed at investigating the impact land-use change has on the existing intersection PHF, thus predicting values per land-use type. Intersections with traffic counts conducted before and after land-use change in vicinity were selected and investigated. The results showed that change in land-use has an impact on the existing PHF. They also assist in identifying the appropriate intersections to predict the PHF per land-use type.

Intersections were identified and analysed, and this led to the development of a design chart showing the predicted PHF per land-use type selected and measures to consider during traffic analysis. Intersection capacity analysis was performed to compare the results using the predicted PHF and the HCM default values. The results showed that traffic flow rate was adjusted by up to 26% when using the default values, 0.92 and 0.95. The results also showed that the default values could overestimate the volume to capacity ratio and the average delay by up to 15% and 35%, respectively. It was then concluded that the use of HCM default values of the PHF for every land-use type will have an effect of the final roadway design results. The computed PHF values for each land-use type were then recommended to be used to ensure fairness and consistency in traffic analysis.

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NOMENCLATURE, TERMS AND CONCEPTS

Nomenclature

CBD – Central Business District
CoT – City of Tshwane
HCM – Highway Capacity Manual
NCHRP – National Cooperation Highway Research Program
PHV – Peak Hour Volume
SIDRA - Signalised and Un-signalised Intersection Design and Research Aid
NMT – Non-Motorised Transport

Terms and Concepts

Delay - The additional travel time experienced by a driver, passenger, or pedestrian.
Capacity - The maximum sustainable flow rate at which vehicles or persons reasonably can be expected to traverse a point or uniform segment of a lane or roadway during a specified time period under given roadway, geometric, traffic, environmental, and control conditions; usually expressed as vehicles per hour, passenger cars per hour, or persons per hour.
Degree of Saturation - The ratio of arrival (demand) flow rate to capacity during a given traffic flow period. It is also known as the volume to capacity ratio.
Level of Service (LOS) - A qualitative measure describing operational conditions within a traffic stream, based on service measures such as speed and travel time, freedom to manoeuvre, traffic interruptions, comfort, and convenience.
Peak Hour Factor (PHF) - A measure of traffic demand fluctuation within the peak hour which can be computed by dividing the peak hourly volume by the hourly equivalent of the peak 15-min flow rate within that peak hour.
Saturation Flow Rate - The equivalent hourly rate at which previously queued vehicles can traverse an intersection approach under prevailing conditions, assuming that the green signal is available at all times and no lost times are experienced, in vehicles per hour or vehicles per hour per lane.

Traffic Impact Assessment (TIA) - A traffic engineering tool commonly used to assess the possible effects of a land development project on the transportation and traffic system.

Traffic Flow Rate - The equivalent hourly rate at which vehicles, bicycles, or persons pass a point on a lane, roadway, or other traffic way; computed as the number of vehicles, bicycles, or persons passing the point, divided by the time interval (usually less than 1 h) in which they pass; expressed as vehicles, bicycles, or persons per hour.

CHAPTER 1 - INTRODUCTION

1.1 General background

Over the last decade, South Africa has experienced development in many areas including transport infrastructure resulting in sudden increase in traffic volume. Road transportation affects land-use, and on the other hand, land-use affects transportation. As a result, it is important to coordinate transportation and land-use planning decisions so that they are complementary rather than contradictory (Litman, 2010b). Therefore, there is need for both transport planning and land-use to support each other. Thus, the existing guidelines for traffic impact study require that all new developments generating more than 50 vehicular trips during the morning and the afternoon peak hour traffic volumes need to be accompanied by a traffic impact assessment report (City Council of Pretoria, 1998; National Department of Transport, 1995).

A traffic impact assessment (TIA) is a traffic engineering tool commonly used to assess the possible effects of a land development project on the transportation and traffic system. The TIA determines whether any transportation improvements are necessary to accommodate the new traffic volumes generated by the development (City Council of Pretoria, 1998).

One of the most important pieces of information in traffic analysis is current traffic volumes. Traffic volume counts should show turning volumes as well as through traffic. Traffic volumes can either be obtained by setting out traffic recorders or by using existing traffic counts that are not more than two years old. The traffic volumes are then adjusted to obtain the peak hour of travel at each key location by using peak hour factors. However, in the absence of field data, peak hour factor default values as provided in the Highway Capacity Manual (2000) can be used during capacity and Level of Service (LOS) analysis. The Highway Capacity Manual (HCM) is a well researched document which takes other countries traffic operation into consideration.

The HCM provides methodologies for evaluating highway, transit and pedestrian facilities that require input parameters that depend on detailed site-specific data. The Highway Capacity Manual (2000) recommends that local traffic data collection be performed for more accurate intersection performance results. The accuracy and the validity of the prediction for performance measures should be considered when applying the results of the analysis (High Capacity Manual, 2000).

This research investigated the effect of land-use change on peak hour factor (PHF). This investigation aimed at establishing local default values of peak hour factor for each land-use type within City of Tshwane Municipality. Such values could replace the default values as recommended in the HCM and use them to suit South African conditions.

1.2 Problem statement

Design of traffic intersection in South Africa by Traffic Engineers and Planners is done on the basis of HCM default values of the PHF and limited traffic counts. The default value of PHF may be significantly affected by a new development in the neighbourhood of the intersection thus underestimating the design flow rate. PHF is one of the input parameters, out of the 63 default values, provided in the HCM that has a high degree of sensitivity (National Cooperation Highway Research Program, 2008).

The LOS arising from such intersection may affect the obligation or the responsibility of the developer and/or the authorities to undertake mitigation measures proposed in the TIA recommendations. The question then is “what value of PHF should be used in roadway design and traffic analysis per land-use type?” The question is important because an estimate from data collected in a single day is not sufficient to answer this question. This, therefore, underscores the need of such a study so as to determine the effect that land-use change will have on the PHF and hence produce national default values.

1.3 Objectives of the study

The overall objective of this study was to investigate the effect of land-use change on traffic peak hour factor within the City of Tshwane Boundaries.

The specific objectives of the study were:

a. To determine the peak hour factor for different land-use types.
b. Develop design charts of PHF which might be considered for inclusion in the National Data Manual.
c. Compare designs using the existing PHF and the proposed PHF values.

1.4 Justification of the study

Highway Capacity Manual (2000) defines the peak hour factor as the hourly traffic volume during the maximum traffic volume hour of the day divided by the peak 15-min flow rate within the peak hour. It further states that the PHF is a measure of traffic demand fluctuation within the peak hour. Traffic demands vary by time of day, hence making use of the PHF. However, PHF has an effect where the final design results could be underestimated and/or overestimated. The application of local PHF values for each land-use type to ensure consistency in traffic analysis and roadway design is recommended.

CHAPTER 2 - LITERATURE REVIEW

2.1 Relationship between transportation and land-use

Land-use (also called development, community design, urban form, spatial planning, and urban geography) refers to how the earth's surface is used, including the location, type and design of human development (Litman, 2010a). On the other hand, transportation is the movement of people and goods from one place to another using rail, air and road. For the purpose of this study, the focus will be on road transportation.

Over the past decade, there has been a growing interest in integrating transportation and land-use planning, with the view that land-use not only influences transportation outcomes but that transportation investments also influence land-use decisions (Waddell, 2001). The reason for integrated transportation-land use models is that land-use and transportation are inter-reliant and need to be treated as such during travel-demand forecasting (Avin, 2007).

It is important to note that the manner in which we use our land (i.e., for agriculture, residential, commercial, industrial development) impacts on our transportation facilities, modes of travel (i.e., cars, buses, bicycles or walking), services and vice versa. This land-use and transportation relationship or cycle is illustrated by describing what commonly occurs when a road is built or improved. Land along the road becomes more accessible. This increased accessibility makes the land more valuable and attractive to developers. As land along the road is developed, traffic volumes and the number of driveways increase. This results in more congestion and a deterioration of the capacity of the road to efficiently move people and goods. The reduced efficiency of the road eventually necessitates roadway capacity improvements that may encourage additional development and the start of a new cycle (Strafford Regional Planning Commission, 2003).

The above concept is also supported by Iacono et al. (2008) who reckon that transportation networks and the spatial patterns of land-use they serve are assumed to mutually influence each other over time. Changes to transportation networks, such as the construction of a new link or expansion of an existing one, eventually influence the location of investment in land, which in turn influences the demand for travel to and from a particular location.

Litman (2008) stated that different land-use patterns favour different types of accessibility thereby affecting the transportation system performance. This is as a result of distribution of destinations, land-use mix, network connectivity and walking conditions. This shows that land-use is as important as mobility in a transportation system. The physical location of transportation infrastructure such as road, rail, and other types of networks, along with the level of accessibility that they provide exert a strong influence on patterns of urban settlement and activity. In turn, the location of activity, particularly new activities such as new housing and commercial development, can influence the location of additions or expansion of transportation networks (Iacano and Levison, 2009).

Transportation and land-use are unavoidably connected. Everything that happens to land use has transportation implications and every transportation action affects land use (Hanson, 1995). Land use and transportation are two sides of the same coin. Decisions that affect one also affect the other. As a result, it is important to coordinate transportation and land use planning decisions so that they are complementary rather than contradictory. This ensures that transport planning decisions support land use planning objectives and land use planning decisions support transport planning objectives. This requires an understanding of how specific land use patterns affect travel (Litman, 2010b).

2.2 Impacts of land-use change on transportation

Changes in land-use systems can modify the travel demand patterns and induce changes in transportation systems. Transportation system evolution, on the other hand, creates new accessibility levels that encourage changes in land-use patterns (Chung and Zhao, 2004). Different types of land-use have different accessibility features. The most significant impact of transportation on land development occurs when access is provided to land. Increased access to land raises its potential for development, and more development generates additional travel. The increased access to land provided by new or upgraded transportation facilities can either induce new development or change existing development patterns (Hanson, 1995).

Land use patterns also affect mobility and accessibility in various ways (Litman, 2008):

a. Density (number of people or jobs per unit of land area) increases the proximity of common destinations, and the number of people who use each mode, increasing demand for walking, cycling and transit.
b. Land use mix (locating different types of activities close together, such as shops and schools within or adjacent to residential neighbourhoods) reduces the amount of travel required to reach common activities.
c. Non-motorized conditions. The existence and quality of walking and cycling facilities can have a major effect on accessibility, particularly for non-drivers.
d. Network connectivity (more roads or paths that connect one geographic area with another) allows more direct travel.

The impact land-use change has on transportation patterns has been extensively researched. Choice of travel patterns can thus be informed by the land-uses in the vicinity of such transportation system. This clearly shows that land-use change has an impact on the travel pattern and traffic flow on the road system.

2.3 Assessment of land development effect on transportation systems

2.3.1 Traffic impact assessment

It was not until in the 1980s that the use of impact studies to assess the amount of traffic generated by a new development became widespread (Dunphy, 2000). Various undesirable consequences of urbanization in many cities have made planners realize that attempts to only encourage city growth by improving facility performances impose greater social costs than benefits. Hence, the need to efficiently manage the usage of existing transportation systems and to minimize the construction of new networks. As a result, many planning tools have been developed and applied to accomplish this task, one of which is a Traffic Impact Assessment (TIA) for land development control (Limapornwanitch et al; 2005).

A TIA is a traffic engineering study meant to determine the effect land-use change or transportation infrastructure may have on existing and future conditions. A complete analysis includes an estimation of future traffic with and without the proposed development, analysis of the traffic impacts, and recommended roadway improvements which may be necessary to accommodate the expected traffic (National Department of Transport, 1995). The existing guidelines for traffic impact study requires that all new developments generating more than 50 vehicular trips during the morning and the afternoon peak hour traffic volumes need to be accompanied by a traffic impact assessment report (City Council of Pretoria, 1998; National Department of Transportation, 1995). These TIA reports have the following intentions (Mohave County, 2007):

a. Identify present and future traffic safety and operational deficiencies without the proposed development.
b. Ascertain operational conditions on the adjacent roadway network when a proposed development is accommodated within the existing transportation infrastructure.
c. Determine whether access to/from the proposed development and generated traffic will degrade traffic safety and operational conditions in the area surrounding the site and impacted by the development.
d. Identify transportation improvements required to maintain traffic safety and operational conditions prior to build-out and occupancy of the proposed development.
e. Provide Authorities with a basis for assessing the transportation implications of approving a subdivision or land development application.
f. Provide a basis for determining a developer’s “fair share” of potential transportation improvement costs required to achieve performance expectations for roadways serving site-generated traffic to/from various regional destinations or adjacent State highway facilities.

Traffic counts data is the basis of all analysis in a traffic impact assessment and careful consideration should be given to the locations, types of counts and duration of counts. Any study can only be as accurate as the data it is based on. For this reason it is important that all traffic studies make special efforts to be thorough and accurate in the collection of traffic counts (Gresham and Partners, 2002).

2.3.2 Level of service and capacity analysis at intersections

Capacity analysis is a set of procedures used to estimate the traffic carrying capacity of transportation facilities over a range of defined operational conditions. The procedures typically result in determination of a Level of Service (LOS). Capacity analysis is carried out in order to design a signalized intersection or to carry out an operational analysis of an existing intersection (Abidin, 2007). LOS is a quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to manoeuvre, traffic interruptions, and comfort and convenience (Highway Capacity Manual, 2000).

Traffic engineers use capacity analysis and LOS to do the following (Laragan, 2003):

a. Determine the number and width of lanes needed for new facilities or for expanding existing facilities.
b. Assess service levels and operational characteristics of existing facilities that are being considered for upgrading.
c. Identify traffic and roadway changes needed for new developments.
d. Provide base values for determining changes in fuel consumption, air pollutant emissions, road-user costs, and noise associated with proposed roadway changes.

Intersections are among the most important elements of a transportation system. It must be appropriately designed to optimize operations based on traffic flow conditions, and to minimize delay for those vehicles passing through the intersection (Kyte et al; 1995). Intersection performance as measured by delay is a function of many factors including, signal timing plan, turning movement traffic demands, traffic stream composition, pedestrian volumes, intersection geometry, temporal variation in traffic demands, the headway distribution of each traffic stream, driver characteristics, weather and road surface conditions and visibility. The impact on intersection performance of day-to-day variability of other factors such as the PHF and turning movement proportions should be examined to make informed decisions on any anticipated movement (Abdy and Hellinga, 2007).

2.4 Peak hour factor use in traffic analysis

The Highway Capacity Manual (2000) defines PHF as “a measure of traffic demand fluctuation within the peak hour” which can be computed by dividing the peak hourly volume by the hourly equivalent of the peak 15-min flow rate within that peak hour. In practice, traffic engineers typically collect traffic movement volume count data in 15 minute intervals over a peak period. On the basis of these data, the peak hour is identified, the peak hour volumes are extracted, and the PHF is computed (or a default value of PHF calibrated for the local condition if used) (Abdy and Hellinga, 2007).

The relationship between the peak 15-min flow rate and the full hourly volume is given by the PHF. Whether the design hour is measured, established from the analysis of peaking patterns, or based on modelled demand, the PHF is applied to determine design-hour flow rates. PHF in urban areas generally range between 0.80 and 0.98. PHF over 0.95 are often indicative of high traffic volumes, sometimes with capacity constraints on flow during the peak hour (Highway Capacity Manual, 2000). The HCM further alerts the analyst to recognize that the quality of the results depends on the quality of the input data. Default values will produce less accurate results than field-measured data due to diverse traffic conditions of a specific place. Table 1 shows typical default values that can be used in the absence of local values.

Table 1: Typical default values for PHF, K, and D

Factor	AREA	
	Urban	Rural
PHF	0.92	0.88
K	0.09	0.10
D	0.60	0.60

(Source, Highway Capacity Manual 2000)

where, *K* is the proportion of Annual Average Daily Traffic (AADT) occurring in the peak hour and *D* is the proportion of peak-hour traffic in the peak direction (Highway Capacity Manual, 2000).

PHF is one of the major parameters in traffic engineering planning, design and operational analysis, either of existing freeways, expressways, and urban arterials or other forms of intersection used to address the effect of traffic flow fluctuation on the highway system (Jimoh and Yusuf, 2006). Abdul Kareem (2006) asserts that a PHF is an important traffic parameter used as measure to justify the improvement of urban streets in terms of the number of lanes speed, limit imposition and turning movements amongst others.

Highway Capacity Manual (2000) defines a default value as a representative value that may be appropriate for estimating an input parameter in the absence of local data. It further states that default values are to be used for planning applications to estimate the LOS, the volume that can be accommodated, or the number of lanes required. Dowling (1994) studied the effect of using default values rather than measured values of the peak hour factor. The study concluded that the use of local values for the peak hour factor, saturation flow rate, and signal progression factor considerably reduced the errors in the delay estimates when the traffic stream was stronger than 85 percent of capacity.

Khatib and Kyte (2000) investigated the sources of error in using default values and their impacts on LOS. The report concluded that one of the important sources of uncertainty was the input data which was propagated through to the final results. The investigation found that errors in the input parameters were responsible for significant bias in the results when they analysed intersections operated at high delays.

Perez-Cartagena and Tarko (2004) in their research concluded that PHF was sensitive to fluctuations in demand, and the PHF measured day after day at a certain intersection during the same rush period varied significantly. PHF has a significant impact on the capacity and quality of service analysis results (National Cooperative Highway Research Program 2008). The report concluded that PHF has a direct impact on the magnitude of the input demand. After applying a PHF of 0.90 to a demand volume of 1,000 Veh/h it increased the demand volume by over 11%. Varying the PHF from 0.60 to 1.00 resulted in a significant increase in delay especially when the demand is high or near saturation as shown in Table 2 (National Cooperative Highway Research Program 2008).

Table 2: PHF Sensitivity on delay at signals

Measures	Low Demand 250 (Veh/approach)				Average Demand 700 (Veh/approach)				High Demand 900 (Veh/approach)			
PHF	0.6	0.8	0.92	1	0.6	0.8	0.92	1	0.6	0.8	0.92	1
% Default Change	-35	-13	0	9	-35	-13	0	9	-35	-13	0	9
Intersection delay s/Veh	20.2	19.5	19.2	19.1	95.7	34.3	28.8	27.0	353	100.1	66.8	47.3
LOS	C	B	B	B	F	C	C	C	F	F	E	D
% Change in Results	5	2	0	-1	232	19	0	-6	279	50	0	-29

(Source National Cooperation Highway Research Program, 2008)

PHF can range from a low of 0.25, indicating all of the peak hour traffic occurs during one fifteen interval, to a high of 1.00, which indicates the peak hour traffic is spread out evenly throughout the hour (Highway Capacity Manual, 2000). Jimoh and Yusuf (2006) concluded that the average volumes obtained from volume studies show that PHF is not a function of the magnitude of the volume but of the demand variation of the facility during the peak hour. While, Perez-Cartagena and Tarko (2005) recommended that PHF should be estimated based on several days of vehicle counting to improve the precision of the average PHF estimated.

The Highway Capacity Manual (2000) specifies a methodology for estimation of average vehicular delay at intersections based on a combination of theoretical and empirical data. This methodology calls for use of a Peak Hour Factor, which extracts the peak 15-min traffic volume from the hourly volume. The Highway Capacity Manual (2000) also advises its users that the methodologies in the Highway Capacity Manual are based on calibrated national average traffic characteristics observed over a range of facilities. Observations of these characteristics at specific locations will vary somewhat from national averages because of unique features. The Highway Capacity Manual (2000) also recommends that due to variation in data as well as prevailing conditions, local data collection should be performed to determine saturation flow rates and lost times, which in turn can lead to more accurate computations.

2.5 Signalised and Un-signalised Intersection Design and Research Aid Solution

Signalised and Un-signalised Intersection Design and Research Aid (SIDRA) is an intersection-based program developed by Australian Road Research Board (ARRB) Transport Research, Ltd. It is an aid for capacity, timing and performance analysis of isolated traffic intersections. SIDRA is a very powerful analytical program for signalized intersections; roundabouts; and yield controlled, two-way stop, or all-way stop-controlled intersections, with up to eight approaches (Sabra et al; 2000).

Typical areas of application are (Sabra et al; 2000):

a. SIDRA can be used to perform lane-by-lane analysis, lane flow calculations, shared lanes and lane blockage, right turn on red, capacities of short lanes, performance measures, variable cycle lengths, variable flow scale, and modelling of unequal lane utilization.
b. The variable cycle length profiles allows agencies to determine the best cycle length and phase sequence based on user-determined criteria for signal optimization. Such functions include minimizing stops and delay, queues, vehicle emissions, fuel consumption, or operating cost.
c. SIDRA has the capability to model upstream and downstream short lanes, slip lanes, shared lanes, and opposed turns with multiple green periods.
d. SIDRA is perhaps the richest Measure of Effectiveness (MOE) based intersection program. It offers MOEs such as total and average delay, degree of saturation, queues, stops, speeds, fuel consumption, emissions, and operating costs.
e. SIDRA is the only program that calculates capacity-based MOEs on a lane-by lane basis for all approaches, in addition to the total intersection MOEs.
f. SIDRA is designed for single time periods, random arrival patterns (but with provision for platoon arrivals generated by coordinated signals), and pre-timed or actuated signals.

g. For roundabout intersections, SIDRA can analyze intersections with up to eight approaches and also has provisions to assume either random or platoon arrivals (bunched vehicles) to analyze the effect of progression from nearby signalized intersections.

Due to the above strength of SIDRA, it was selected to be used in this research.

2.6 Inferences from the literature review

The literature review has extensively covered the concepts of Land-use and Transportation. As a broad term, transportation was simplified to bring out the issue of sensitivity and impact of the peak hour factor on the final results during capacity analysis. The following were covered by the literature:

a) Land-use change has the ability to adjust the traffic demand and distributions thereby encouraging changes in the transportation systems. Therefore, land-use and transportation planning need to be treated as a unit rather than in isolation.
b) A traffic impact assessment is widely used as a tool to propose mitigating measures to accommodate new development trips on the road network.
c) Peak hour factor is an important input parameter that influences the results during capacity and level of service analysis.
d) Local PHF values should be predicted and used to prevent bias on intersection capacity and LOS results. The results arising from such intersections may affect the obligation or the responsibility of the developer and/or the authorities to undertake mitigation measures indicated in the TIA recommendations. The question then is "what value of PHF should be used in roadway design and traffic analysis per land-use type?" The aim of this study is to answer the question and develop local default values to be used during traffic analysis.

The subsequent Chapters detail the methodology employed, data collected, details on the analysis done, discussion of results, and the conclusions arrived at and recommendations made.

CHAPTER 3 - STUDY AREA AND RESEARCH METHODOLOGY

3.1 Study area

The City of Tshwane (CoT) is the largest municipality in Gauteng, and is among the six biggest metropolitan municipalities in South Africa as shown in Figure 1. It covers an area of 6368 square kilometres. It is located at Coordinates: 25°40′0″S 28°10′0″E - Wikipedia http://en.wikipedia.org/wiki/City_of_Tshwane_Metropolitan_Municipality. The following towns and townships form part of the Municipality's area: Pretoria, Centurion, Akasia, Soshanguve, Mabopane, Atteridgeville, Ga-Rankuwa, Winterveld, Hammanskraal, Temba, Pienaarsrivier, Crocodile River, Metsweding, Kungwini and Mamelodi. The CoT was established on 5th December 2000 when the local authorities which had previously served the greater Pretoria and surrounding areas were integrated. In 2010, Metsweding and Kungwini municipalities were merged with the City of Tshwane.

Figure 1: Municipalities in the Gauteng Province Map

(Source: Gauteng Map 2010)

3.2 Data collection

In this section, it is indicated how the specific objectives were achieved. It details what data was required and how it was obtained, analysed and the tools used for the analysis.

3.2.1 Secondary data collection

This step involved collection of all existing traffic counts data and CoT Arc Map information. Traffic counts conducted between 2005 and 2010 and information on the zoning history of the properties where land-use change or extension of rights took place were obtained.

The data collection was accomplished by:

- Visits to the Traffic Engineering and Operations Section of CoT;
- Visits to the City Planning Department of CoT and
- Visits to ITS Engineers, EDS Engineers and Civil Concepts Engineers offices.

The data collected from CoT officials and during site visits included:

- Traffic counts data;
- Zoning certificates before and after development;
- Land-use maps and
- Current intersection operation and configuration.

The information collected was used to select intersections with traffic counts data taken before and after change in land-use or extension of development rights. The information gave a good representation on how land-use change influences the existing traffic peak hour at the intersection.

3.2.2 Identification of intersections

Traffic counts obtained and the CoT Arc Map were used to identify intersections. Arc Map is a geospatial processing program, and is used primarily to view, edit, create, and analyze geospatial data. The CoT Arc Map was used to view changes in land-use at the vicinity of intersection with traffic counts data. Traffic counts conducted before 2005 were not used since the CoT Arc Map could only show aerial photos for the years 2005, 2007 and 2009.

A locality map indicating all road intersections within CoT where traffic counts were conducted was used. The locality map was obtained from the CoT traffic counting team. Land-use changes in the vicinity of such intersections were identified by conducting site inspections and using the CoT Arc Map. Choice of intersection study sites was thus informed by specific land-uses of interest that had substantial traffic information already available.

The methodology followed to select the intersections with existing traffic counts and change in land-use was based on the following criteria:

- Change in land-use next to intersections with traffic counts.
- Intersections with traffic counts taken before and after any change in land-use.

To identify the intersections, changes in land-use using the Arc Map for all traffic counts conducted in 2005 to 2008 were investigated. Intersections with traffic count data taken before and after any land-use change were selected. Traffic operations and historical information of the intersections selected were investigated. The information collected included the previous and current intersections configuration and traffic signal settings, if signalised. The following intersections that conformed to the criterion used were selected:

a. John Vorster Drive and Nellmapius Drive Intersection (Figure 2)
b. Lynnwood Road and Hans Strijdom Drive Intersection (Figure 3)
c. Zambesi Drive and Breed-Visvanger Streets Intersection (Figure 4)
d. Simon Vermooten Drive and Lynnwood Road Intersection (Figure 5)
e. Atterbury Road and Manitoba-Alsatian Streets Intersection (Figure 6) and
f. Rietspruit Road and Yen Street Intersection (Figure 7)

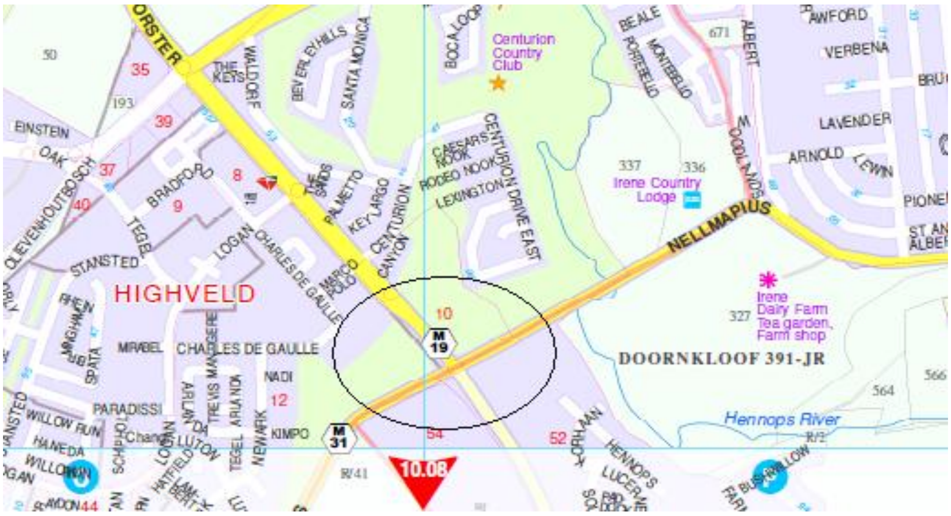


Figure 2: John Vorster Drive and Nellmapius Drive Intersection Map

Figure 3: Lynnwood Road and Hans Strijdom Drive Intersection Map

Figure 4: Zambesi Drive and Breed / Visvanger Street Intersection Map

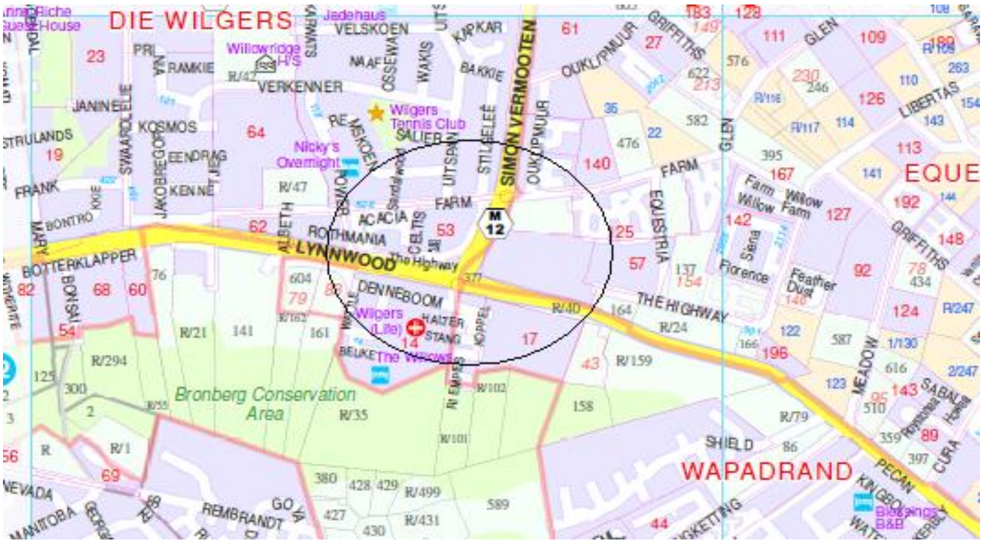


Figure 5: Simon Vermooten Drive and Lynnwood Road Intersection Map

Figure 6: Atterbury Road and Manitoba / Alsatian Street Intersection Map

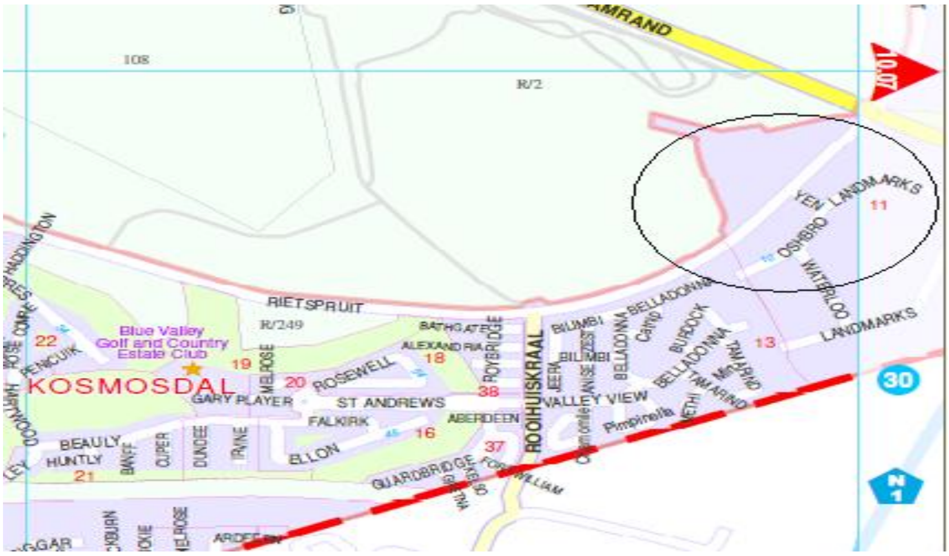


Figure 7: Rietspruit Road and Yen Street Intersection Map

Traffic counts data obtained were captured on an already prepared excel spreadsheet. Appendix A shows an example of the spreadsheet used. The purpose of the spreadsheet was to automatically calculate the peak hourly traffic volume, the peak 15-min traffic volume thereby producing the Peak Hour Factor (PHF) at each intersection. The directional splits at each intersection approach were calculated to indicate inbound and outbound stream traffic distinction. Equation 1 obtained from the Highway Capacity Manual (Highway Capacity Manual, 2000) was used to calculate the traffic PHF. This is the only formula used to calculate the traffic PHF as prescribed in various traffic engineering manuals.

$$PHF = \frac{V}{4V_{15}} \quad \textbf{(1)}$$

where:

PHF = Peak Hour Factor

V = Hourly traffic volume (Veh/h)

V_{15} = Traffic Volume during the peak 15 minute of the peak hour (Veh/15min)

The results obtained were used to signify the impact land-use change and/or expansion of land development had on the existing PHF at the intersection. The results were also used as a guide in selecting appropriate intersections to predict PHF for each land-use type. These implications are discussed in Chapter 4.

3.2.3 Land-uses and intersections to compute PHF

Land-uses that were constantly established and having an impact on the day-to-day traffic operations on the road network were identified. This was done in consultation with the City of Tshwane city planning department and traffic engineering firms operating within the city. The land-uses identified were as shown in Table 3. Table 3 also shows the intersections selected at different locations closer to such land-uses. Maps of intersections selected are shown in Appendix B. Results obtained from the methodology in sub-section 3.2.2 were used as a guide to select the intersections. A minimum of three intersections per land-use type were used to determine PHF variation and traffic manoeuvre at different locations and to eliminate individual bias.

Table 3: Intersections per land-use type

Land-use	Intersections	Area
Residential	Church Street and Strachan/Rod Street	Lotus Garden
	Zambesi Drive and Zambesi Estate Street	Montana
	Brits Road and Doreen Avenue	Amandasig
	Hebron Road and Umphafa Street	Soshanguve
	Cura Avenue and Stellenberg Road	Willowglen
	Stonewall Boulevard and Old Farm Road	Faerie Glen
	Old Farm Road and Hans Strijdom Drive	Faerie Glen
	Witch Hazel Avenue and Eco Park Boulevard	Highveld
	John Vorster Drive and Karee Street	Irene
Office	Meiring Naude and Quitin Brand Street	Persequorpark
	Meiring Naude Street and CSIR Entrance	Lynnwood Manor
	Soutpansberg Road and Foreign Affairs Access	Rietondale
	Meiring Naude and Hotel Street	Persequor
	Witch Hazel Avenue and Eco-park Boulevard	Highveld
	Matroosberg Street and River Walk Park Access	Ashlea Gardens
Industrial	Waltloo Road and Kuit Street	Waltloo
	Pretoria Street and Fakkel Street	Silverton
	Ernest Opperheimer and R566	Rosslyn
	Dykor Street and Moreleta Street	Silverton
	Voortrekker Road (R55) and Ellman Street	Sunderland Ridge
Institutional: Schools	Boeing Street and Hans Strijdom Road	Erasmuskloof
	Soutpansberg Road and Wren Street	Hillcrest
	Daan de Wet Nel Drive and Rene Road	Winternest
	Anthesis Street and Cyme Crescent	Lotus Garden
Retail	Garstfontein Road and Philadelphia Avenue	Pretoriuspark
	De Villebois Mareuil Drive and Woodlake Boulevard	Pretoriuspark
	Heinrich Drive and Madelief Avenue	Karenpark
	Maphalla Drive and J Letwaba Street	Mamelodi
Medical: Hospital	Church Street and Kalafong	Atteridgeville
	Simon Vermooten and Lynnwood Drive	Die Wilgers
	Cliffton Avenue and Cantonment Road	Lyttelton Manor
	Voortrekker Road and Malan Street	Capital Park
Places of Public Worship	De Villebois Mareuil Drive and Feverwood Road	Moreletapark
	Genl. Louis Botha Drive and Hatfield Christian Church Access	Waterkloof Glen
	Nellmapius Drive and Jan Smuts Avenue	Doornkloof

The availability of traffic counts data at the selected intersection was investigated. Where there were no traffic counts data readily available, field data collection was conducted. Manual traffic count method was used during data collection. This was because manual counts collect specific information that cannot be efficiently obtained through automated means. Tally sheets were used to record the traffic volumes. Traffic Observers recorded data with ticks on a pre-prepared form from 06H00 during the AM Peak period to 18H00 during the PM Peak period.

An investigation was conducted prior to collecting traffic data to allow for the determination of a typical range of peak hour traffic movements on a roadway facility. A count interval of 15-min in an hour was used to obtain the traffic volumes. This was because of the PHF equation, as shown in equation 1, which uses the 15-min interval to calculate the PHF. The following steps for manual traffic volume counting were followed (Gresham and Partners, 2002):

a. Preparation: determined the type of equipment to use, the field procedures to follow, and the number of observers required. Labelled and organized tally sheets. Each sheet included information about the location, time and date of observation, and weather conditions.
b. Selected observer location(s). Data collectors positioned where they have a clear view of traffic and were safely away from the edge of the roadway.
c. Labelled data forms and recorded observations on site. The observers recorded the location, time and date of observation, and weather conditions. Data collectors recorded the traffic volume passing an intersection approach for each hour at 15 minutes intervals.

Traffic counts data obtained were captured into an excel spreadsheet mentioned in sub-section 3.2.2. The results for each land-use type produced were presented in Chapter 5 using tables. The results presented were only at intersection approaches able to relate a PHF to a particular land-use type. The results obtained were further analysed and summarized using the STATA data analysis and statistical software where the PHF per land-use type was determined, thus meeting the first specific objective.

Specific parameters associated with each land-use type in relation to the produced PHF were identified from the summarized results. The specific parameters included the peak hours, peak periods, days of the week and the traffic directional splits. These specific parameters could be a guide during traffic analysis for each land-use when employing the produced PHF. A design chart in the form of a table showing the PHF for each land-use type with the appropriate specific parameters was developed, thus meeting the second specific objective.

One intersection for each land-use was used to analyse the capacity and Level of Service (LOS) using the SIDRA intersection software. The computed PHF values for each land-use and the HCM default values of the PHF were separately used to compare the intersections measure of effectiveness. The comparison was performed to show the differences in traffic flow rate, intersection delays, degree of saturation and the LOS, thus meeting the third specific objective.

The implications of the results obtained and how the overall objective of the study was met are as discussed in Chapter 5.

CHAPTER 4 – INTERSECTION DATA ANALYSIS DUE TO LAND-USE CHANGE

4.1 Selection of intersection for the study

Traffic data collected and the CoT Arc Map were used to select the appropriate intersections for the study. This information was used to identify the intersection with traffic counts conducted before and after land development took place in the vicinity. Six intersections were selected for analysis. Traffic data from the identified intersections was used to indicate the impact new developments could have on the existing traffic operating conditions at the intersection as well as assisting in selecting appropriate locations to predict the PHF. The following intersections were identified:

a. John Vorster Drive and Nellmapius Drive Intersection
b. Lynnwood Road and Hans Strijdom Drive Intersection
c. Zambesi Drive and Breed-Visvanger Streets Intersection
d. Simon Vermooten Drive and Lynnwood Road Intersection
e. Atterbury Road and Manitoba-Alsatian Streets Intersection and
f. Rietspruit Road and Yen Street Intersection

The aerial photos and geometric layout of each intersection selected showed the following results:

a. Nellmapius John Vorster Drive Intersection

This intersection is situated in the Southern Region of Tshwane in Centurion. The pictures in Figures 8 show the development growth in the area between 2005 and 2009. The data collected from the CoT City Planning Department was used to indicate the zoning rights before and after development. The properties were zoned as retail, offices and residential before and after development.

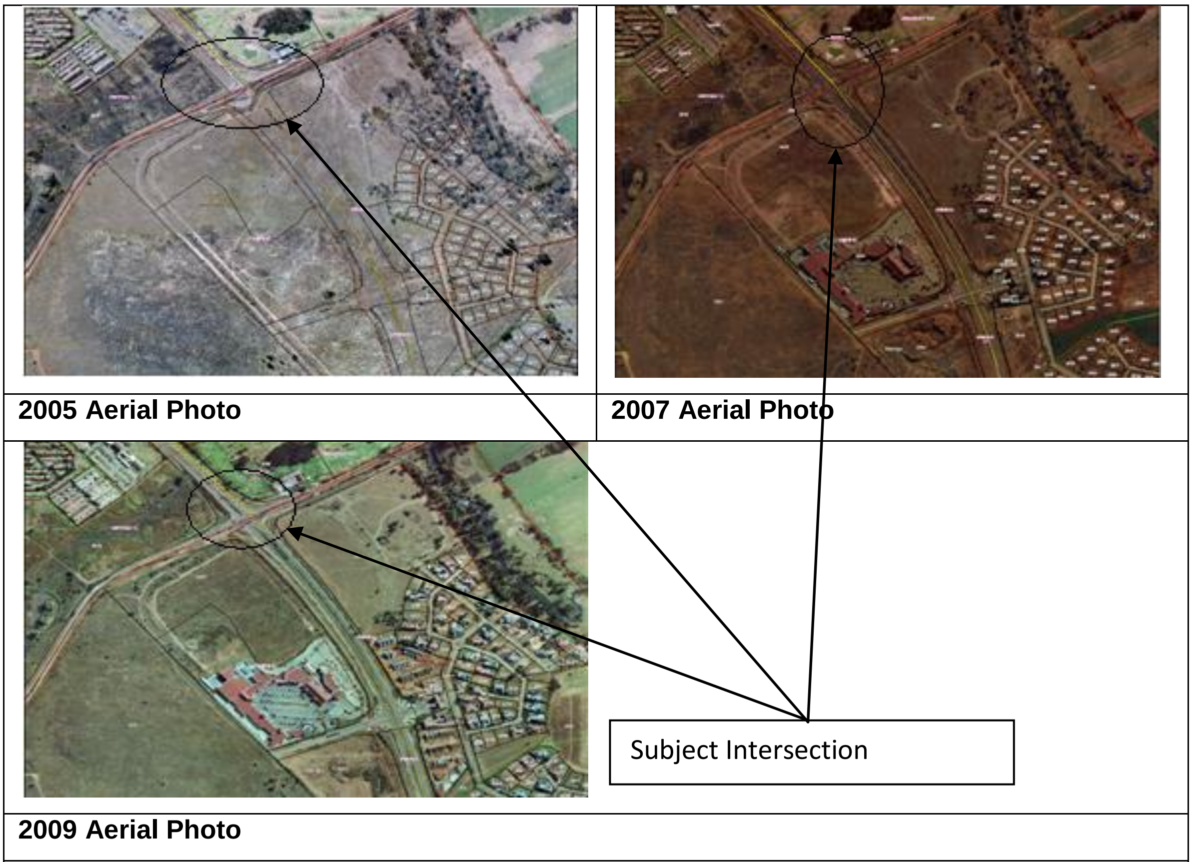


Figure 8: Aerial Photos at Nellmapius and John Vorster Drive Intersection

Figures 9 and 10 show the intersection geometric layout before and after it was upgraded. The intersection was upgraded to provide access to school, offices, retail and residential developments that took place south east of the intersection.

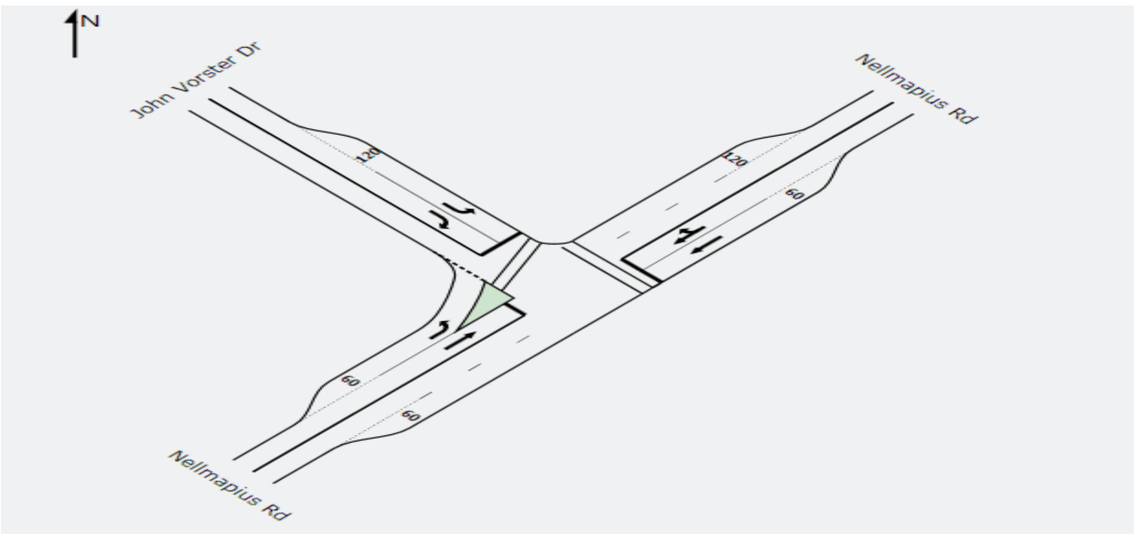


Figure 9: Nellmapius Drive and John Vorster Drive Intersection Configuration before upgrading

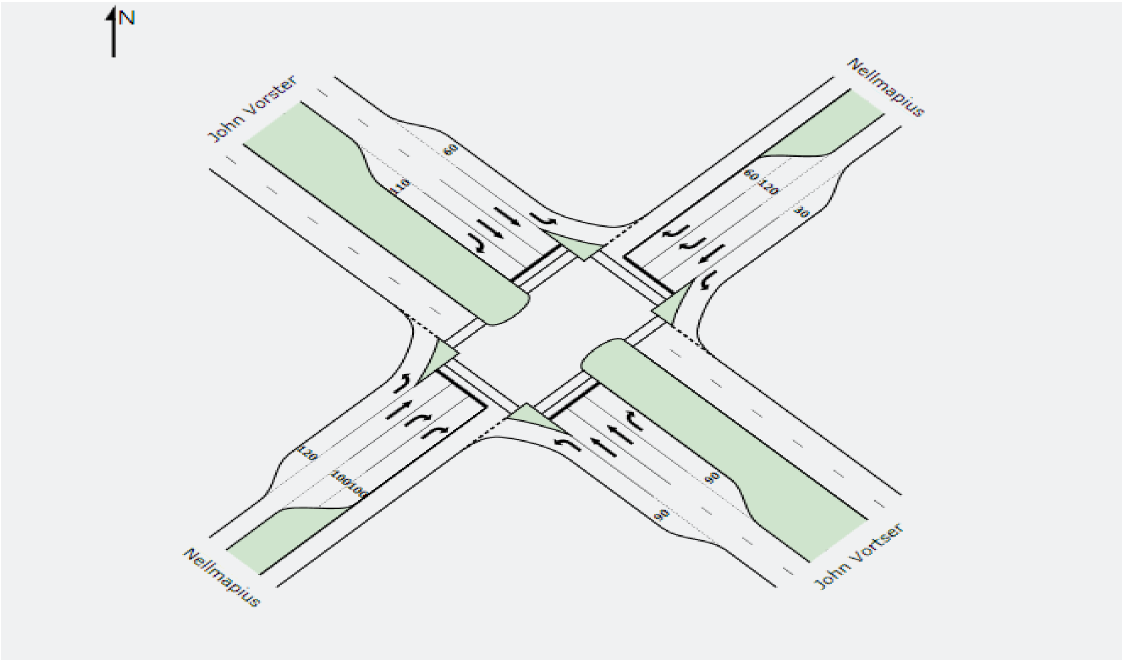


Figure 10: Nellmapius Drive and John Vorster Drive Intersection Configuration after Upgrading

The traffic counts at the intersection were conducted on the 28th May 2007 and 21st April 2010 when it was entirely upgraded. The traffic counts results are presented and discussed in sub-section 4.2.

b. Lynnwood Road and Hans Strijdom Drive Intersection

This intersection is situated in the Eastern Region of CoT in Willow Glen. Figure 11 shows the growth in development in the vicinity of the intersection between 2005 and 2009. The zoning rights obtained from the CoT City Planning Department indicated that new developments in the area were for motor dealership, service centre, residential and retail.

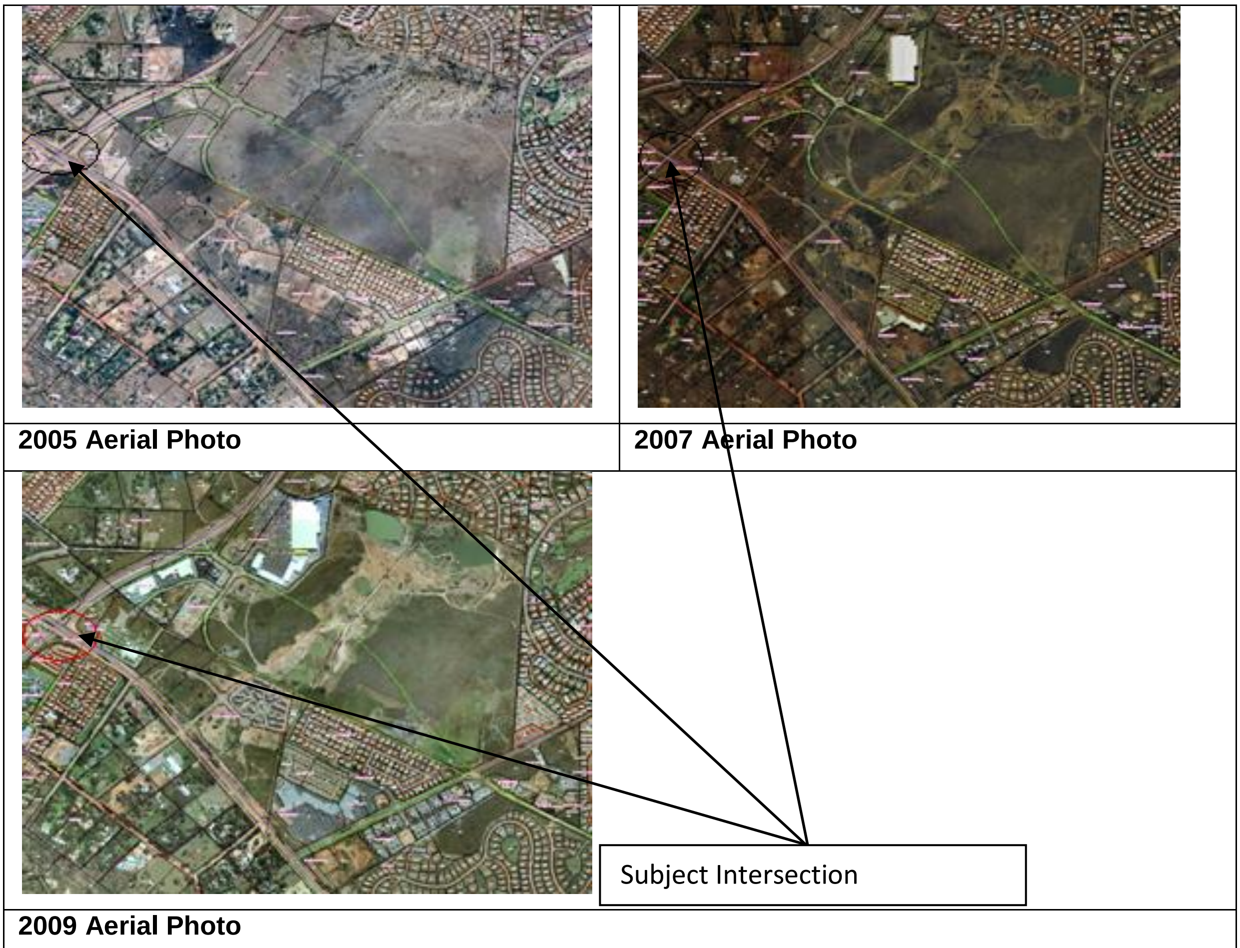


Figure 11: Aerial Photos at Lynnwood Road and Hans Strijdom Drive Intersection

Figure 12 show the intersection geometric layout affected by development in the area. No road improvement took place at the intersection since 2005 although traffic signal settings were done to accommodate new development trips.

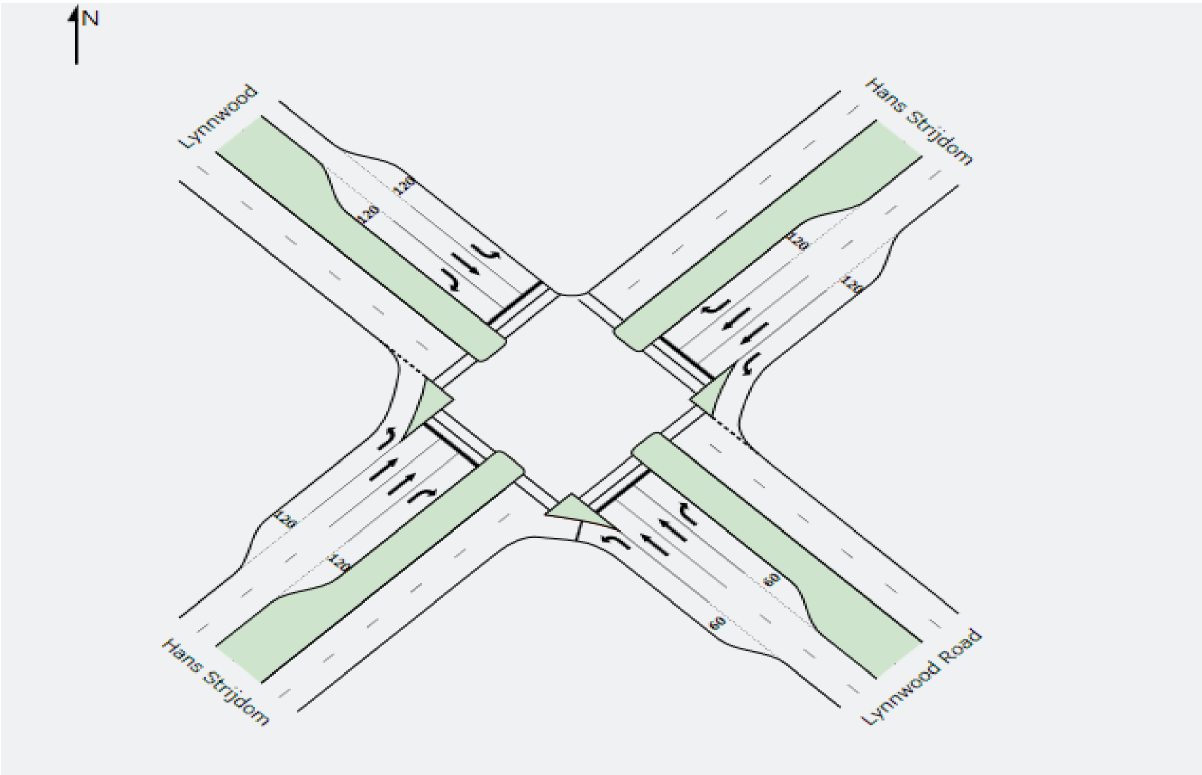


Figure 12: Lynnwood Drive and Hans Strijdom Drive Intersection Configuration

Traffic counts at the intersection were conducted on the 15th June 2006, 15th April 2008 and 29th April 2010. Motor dealership, service centre, residential and retail developments took place at the eastern side of the intersection over time hence it was selected. The traffic counts results are presented and discussed in sub-section 4.2.

c. Zambesi and Breed / Visvanger Street Intersection

This intersection is situated in the North Eastern Region of CoT in Montana. Figure 13 shows the development growth in the vicinity of the intersection. The information obtained from the CoT City Planning Department indicated that the nearby properties were zoned for shops, business buildings, showrooms, warehouses, motor dealerships, place of refreshment including take-away restaurants and garden centres.

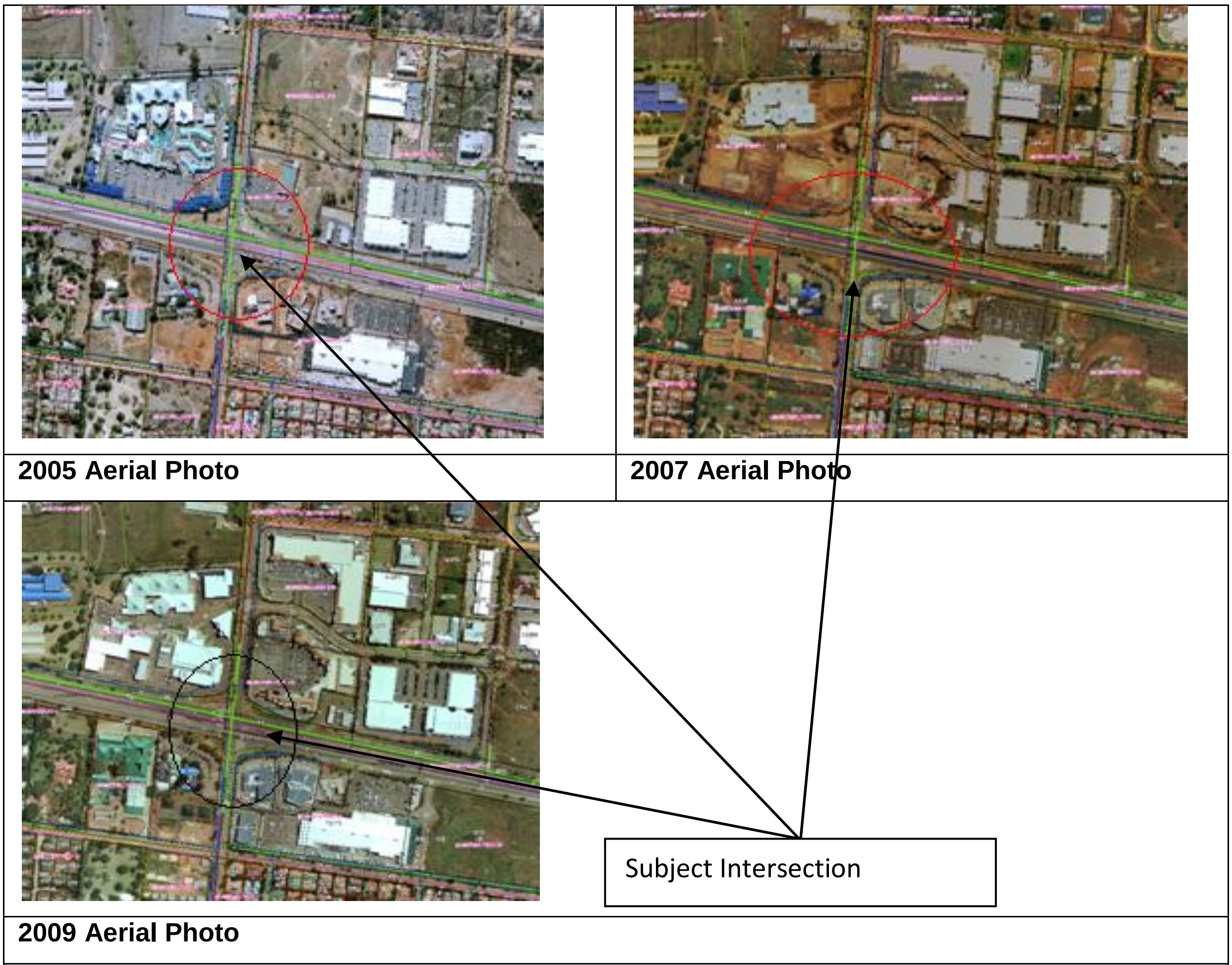


Figure 13: Aerial Photos at Zambesi Drive and Breed / Visvanger Street Intersection

Figures 14 and 15 show the intersection geometric layout before and after it was upgraded. It is the first four-legged intersection from the N1 highway along Zambesi Drive. The intersection is signalised and carries high traffic volumes during the AM and PM peak periods.

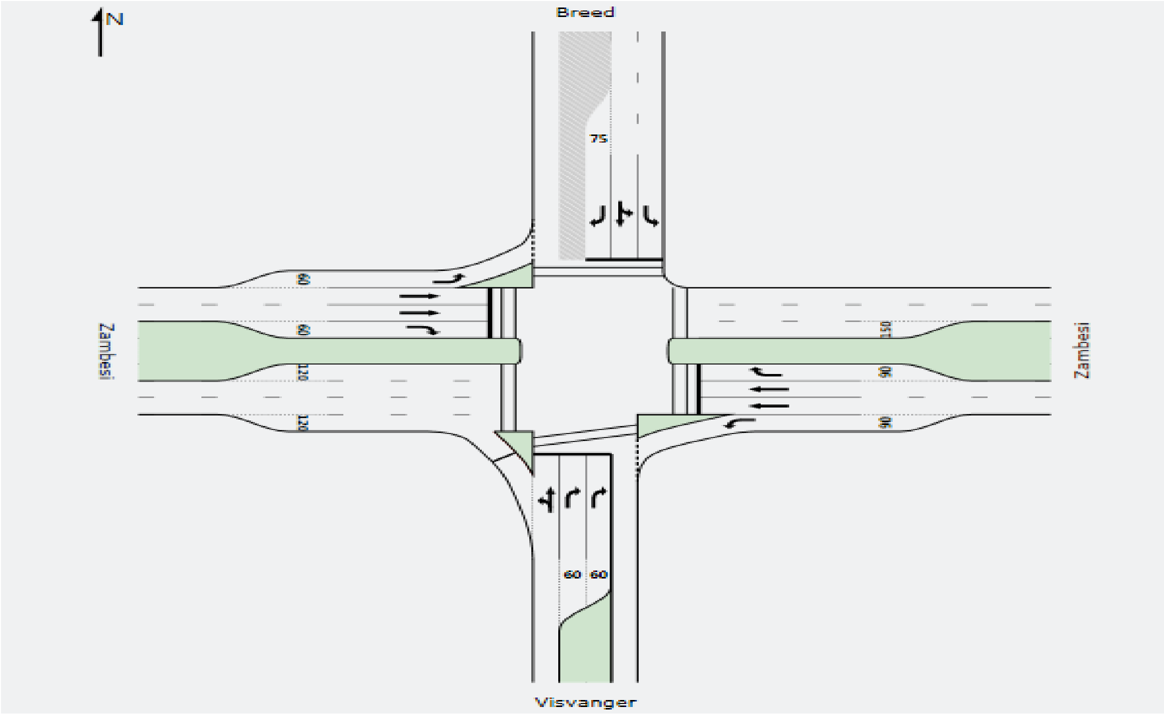


Figure 14: Zambesi Drive and Visvanger / Breed Street Intersection Configuration before Upgrading

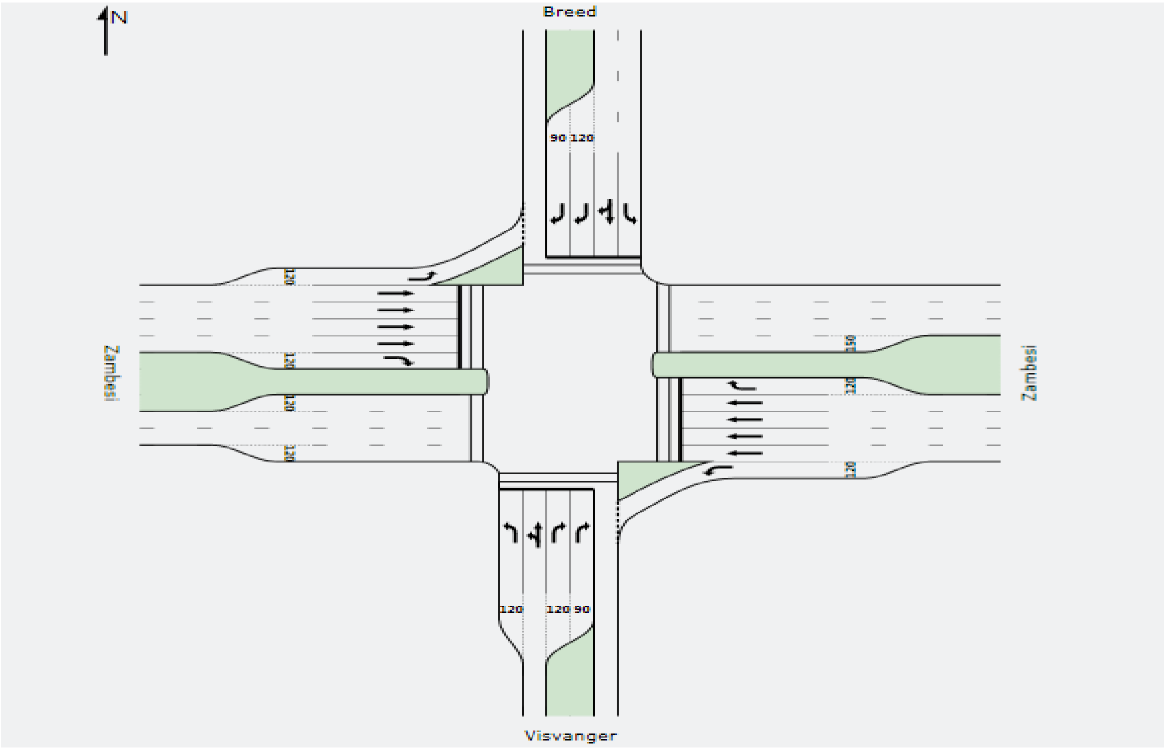
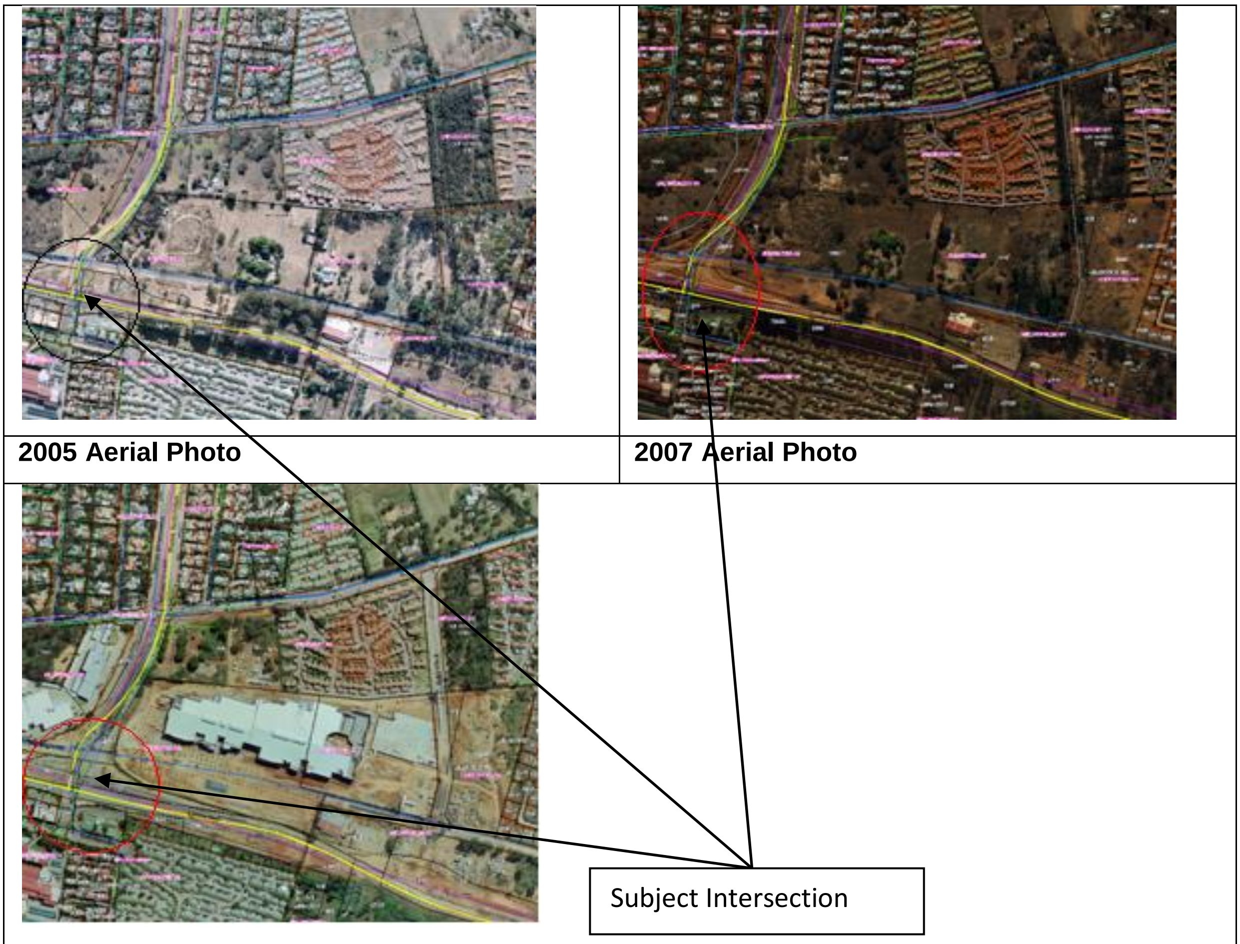


Figure 15: Zambesi Drive and Visvanger / Breed Street Intersection Configuration after Upgrading

Traffic counts at the intersection were conducted on 30th May 2005 and 17th November 2008. Due to new developments in the vicinity the intersection was upgraded to accommodate the traffic volumes. The intersection was selected on the basis of it being affected by new developments in the area. The traffic counts results are presented and discussed in sub-section 4.2.

d. Simon Vermooten Drive and Lynnwood Road Intersection

This intersection is situated in the Eastern Region of CoT in Die Wilgers. Figure 16 shows the development growth next to the intersection. The properties in the vicinity of the intersection had retail and motor dealership buildings rights before and after development.



2005 Aerial Photo

2007 Aerial Photo

2009 Aerial Photo

Figure 16: Aerial Photos at Simon Vermooten Drive and Lynnwood Road Intersection

Figures 17 and 18 show the intersection geometric layout before and after development took place. The intersection was upgraded as part of the development proposal and it was completed before the development could open. The intersection carries high traffic volumes during the AM and PM peak periods. It is a link between the Tshwane Central Business District (CBD) and the eastern suburban area of the City.

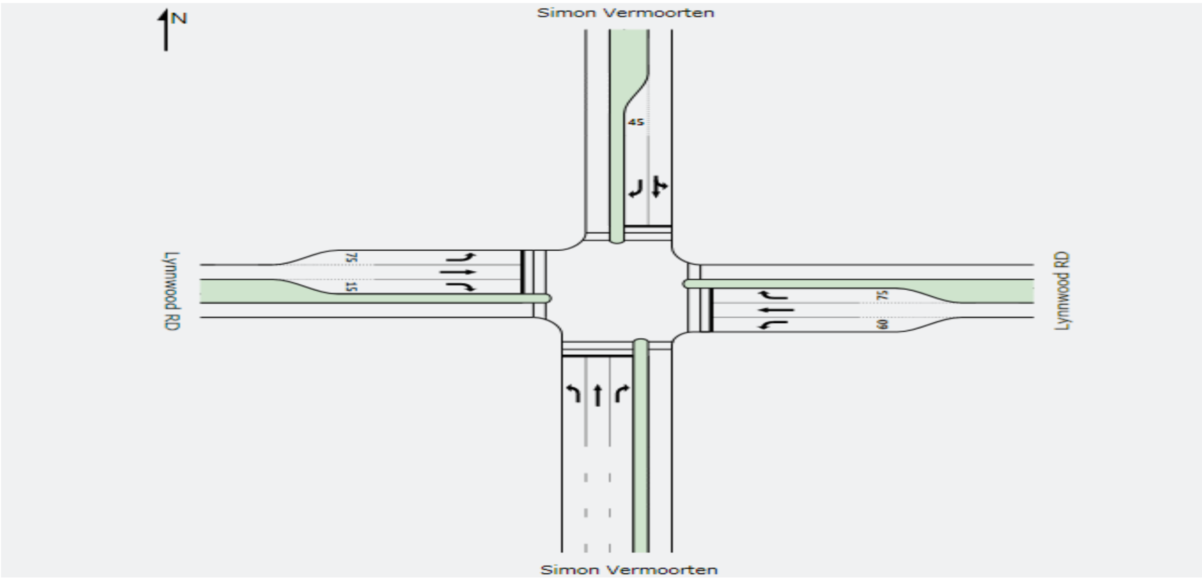


Figure 17: Simon Vermooten Drive and Lynnwood Road Intersection Configuration before Upgrading

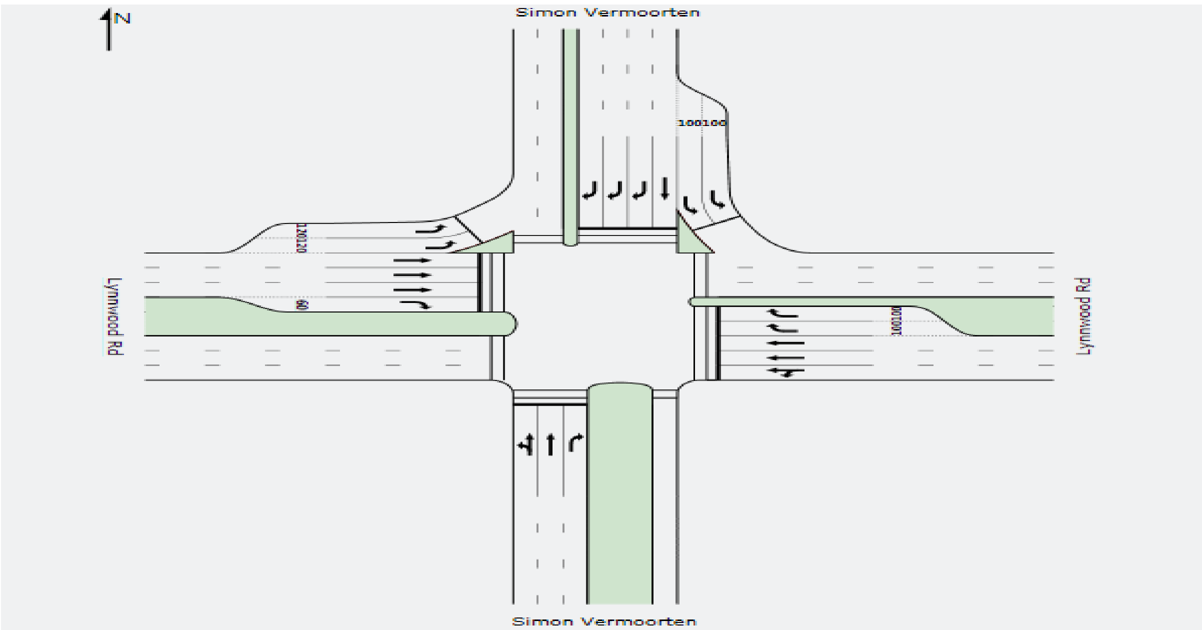


Figure 18: Simon Vermooten Drive and Lynnwood Road Intersection Configuration after Upgrading

Traffic counts at the intersection were conducted on 19th May 2005, 06th March 2006 and 13th October 2010. The counts were conducted before and after the intersection was upgraded, hence it was selected for analysis. The traffic counts results are presented and discussed in sub-section 4.2.

e. Atterbury Road and Manitoba / Alsatian Street Intersection

This intersection in situated in the Eastern Region of CoT in Faerie Glen. Figure 19 shows development growth at the north western side of the intersection. Data collected from the CoT City Planning Department indicated that the property had development right for a filling station, shops, offices and place of refreshment.

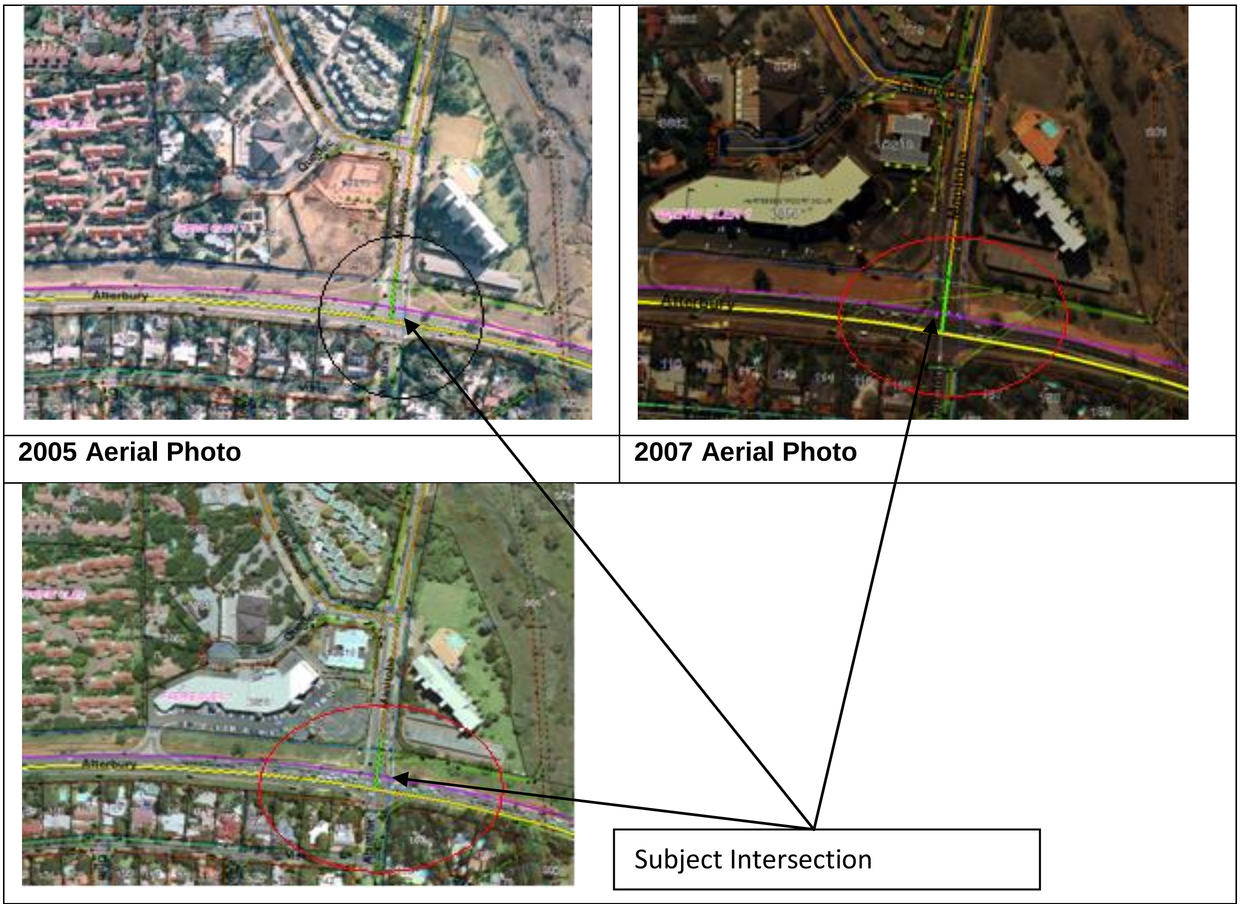


Figure 19: Aerial Photos Atterbury Road and Manitoba / Alsatian Street Intersection

Figures 20 and 21 show the intersection geometric layout before and after it was upgraded. The intersection carries high traffic volumes during the AM and PM peak periods. It is surrounded by mix land-use developments. The upgrading at the intersection took place as a result of the new development north west of the intersection.

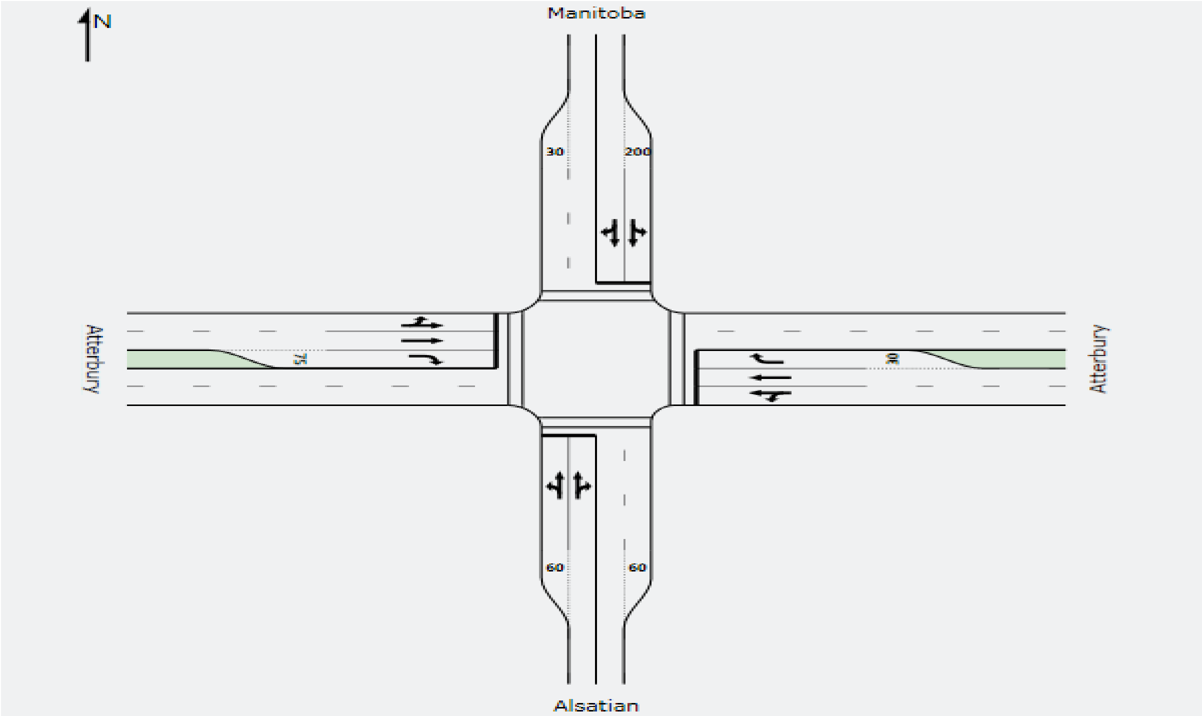


Figure 20: Atterbury Road and Manitoba / Alsatian Street Intersection Configuration before Upgrading

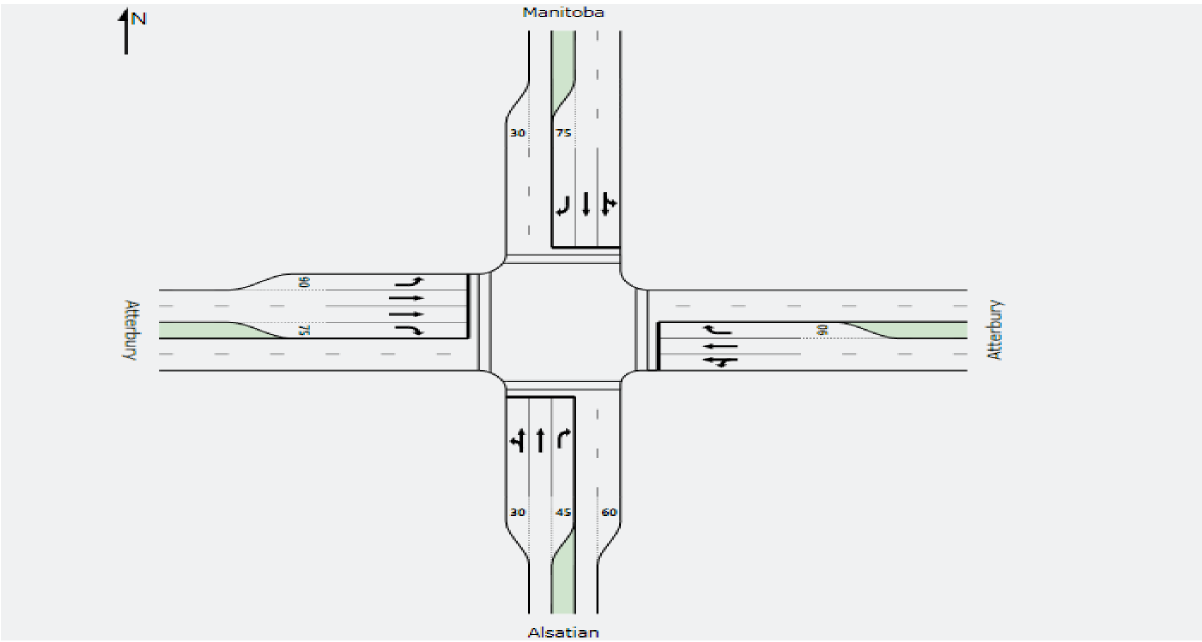
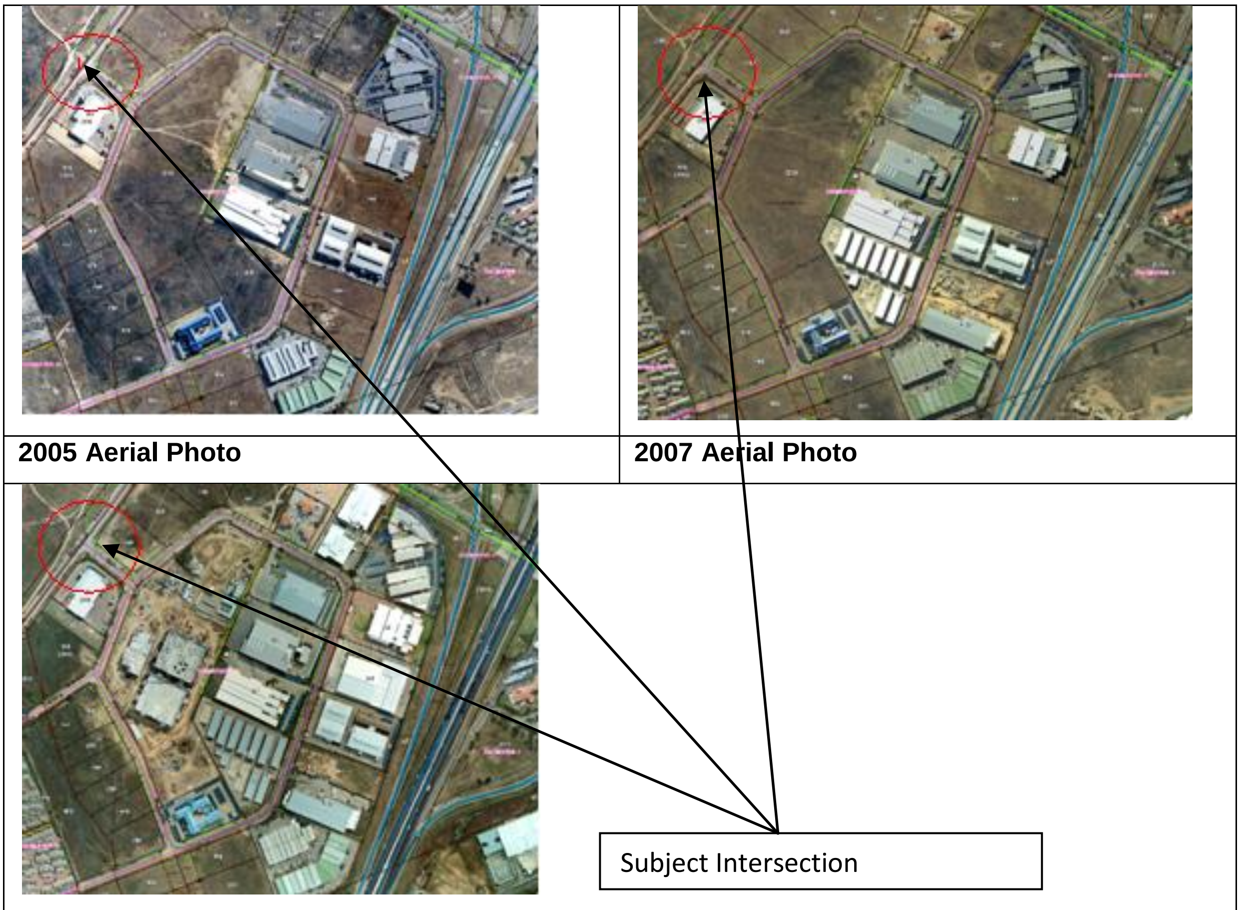


Figure 21: Atterbury Road and Manitoba / Alsatian Street Intersection Configuration after Upgrading

Traffic counts at the intersection were conducted on 3rd May 2005 and 12th June 2008. The intersection was selected as it had change in land-use before and after traffic counts were conducted. The traffic counts results are presented and discussed in sub-section 4.2.

f. Rietspruit Road and Yen Street Intersection

This intersection is situated in the Southern Region of CoT in Kosmosdal. Figure 22 shows the development growth in the area. The data collected from the CoT City Planning Department indicated that the properties east of the intersection had development rights for offices and light industrials.



2005 Aerial Photo

2007 Aerial Photo

2009 Aerial Photo

Figure 22: Rietspruit Road and Yen Street Intersection

Figure 23 shows the intersection geometric layout and no upgrading took place as part of development expansion. The intersection is three-way stop controlled with priority on north-east and south-west movements. With growth in development rights, the traffic from south-east of the intersection find it difficult to access and exit the main stream due to high traffic volume during the AM peak and PM peak periods.

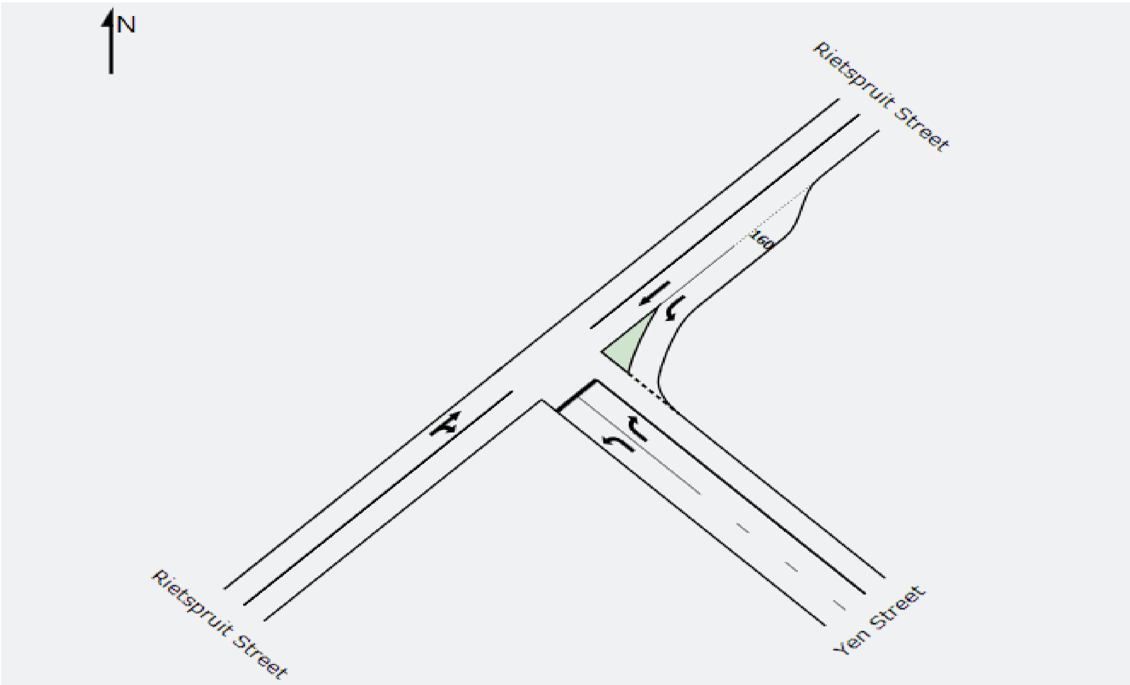


Figure 23: Rietspruit Street and Yen Street Intersection Configuration

Traffic counts were conducted on 10th March 2005, 19th April 2007 and 18th January 2011. Due to development expansion over time and an increase in traffic volumes, the intersection was selected. The traffic counts results are presented and discussed in sub-section 4.2.

4.2 Traffic data analysis obtained before and after land-use change

The main source of information for this research was traffic counts data. Any traffic study requires accurate traffic counts. Determining how many vehicles may use a section of road or an intersection is necessary for analysing and timing traffic signals, determining capacity and estimating the LOS that will be needed. Traffic counts data from the six (6) selected intersections were captured into a Microsoft Excel Spreadsheet as shown in Appendix A. The purpose of the spreadsheet was to calculate the peak hourly traffic volume, the peak 15-min volume and the PHF. It was also important to indicate the peak hours where the peak hourly traffic volumes were likely to occur. Equation 2, similar to equation 1 in sub-section 3.2.2, obtained from the Highway Capacity Manual (Highway Capacity Manual, 2000) was used to calculate the traffic PHF.

$$PHF = \frac{V}{4V_{15}} \tag{2}$$

where:

PHF = Peak Hour Factor

V = Hourly traffic volume (Veh/h)

V_{15} = Traffic Volume during the peak 15 minute of the peak hour (Veh/15min)

The ratio of hourly traffic volume divided by maximum rate of flow, PHF, was used to capture the stability of traffic volume distribution in an hour. In broad-spectrum, PHF was used to display the evenness of peak-hourly flow in 15-min intervals. Small values of the PHF show that the incoming traffic flow during a peak hour is not evenly distributed. Values of PHF close to 1.0 indicate that the incoming traffic flow is evenly distributed. The peak hour traffic volume, the 15-min peak traffic volume, the PHF and the peak hours at each intersection were determined. Only the affected approaches results are presented because other intersection approaches indicated results that could not be related to any land-use in the surrounding area.

Two intersections with two different scenarios were analysed. Scenario 1 represents land-uses that gained access from one intersection whereas scenario 2 represents the land-uses that gained access from two or more intersections on the road network.

a. Scenario 1

Scenario 1 represents the land-uses that gained access from one intersection in the surrounding area. Nellmapius and John Vorster Drive Intersection as shown in Figure 24 was used to discuss scenario 1. Similar behavioural patterns at other selected intersections were noted. The intersections included Rietspruit Road and Yen Street, and Hans Strijdom Drive and Lynnwood Road intersections. The intersection was upgraded from a three legged to a four legged signalised intersection as a result of new development trips from the eastern side of the intersection (Figure 9 and 10). Nellmapius Drive serves as a link road whereas John Vorster Drive from north-west of the intersection is where mix land-use developments and the Centurion Central Business District (CBD) are. Land-uses found on the eastern side of the intersection were residential, school, offices and retail development.

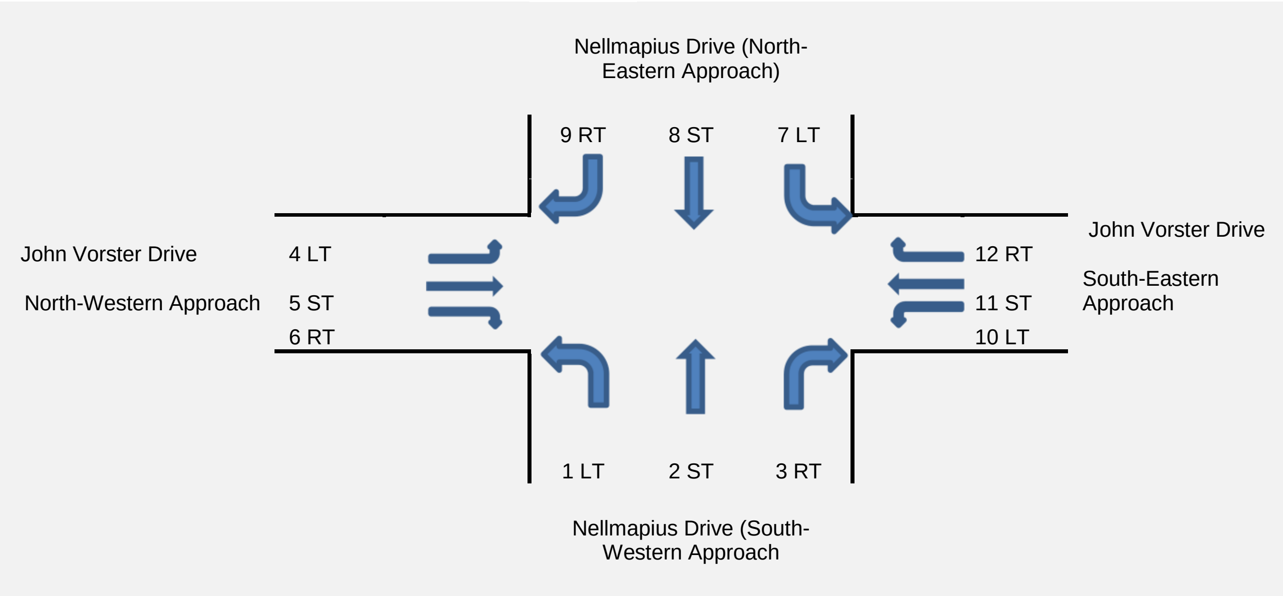


Figure 24: Nellmapius and John Vorster Drive Intersection Turning Movements

where:

RT = Right Turning movement

ST = Straight Through movement

LT = Left Turning movement

Traffic movement 10-LT, 11-ST and 12-RT represented the outbound stream while traffic movement 3-RT, 5-ST and 7-LT represented the inbound stream at the affected intersection approach. Table 4 shows the results for the traffic count data conducted in 2007 and 2010 at the affected South Eastern approach of the intersection.

The outbound stream peak hour traffic volume increased from 126 Veh/h in 2007 to 553 Veh/h in 2010 during the AM peak period and from 377 Veh/h in 2007 to 486 Veh/h in 2010 during the PM peak period. The increase in traffic volumes was as a result of new developments from the east of the intersection. While there was an increase on the peak hour traffic volumes the PHF decreased. It decreased from 0.81 to 0.61 and 0.87 to 0.81 during the AM and PM peak, respectively. It was also noted that there was change in the peak hour during the AM and PM peak periods. It changed from 08:00 – 09:00 to 07:15 – 08:15 and 16:45 – 17:45 to 15:30 – 16:30 during the AM and PM peak periods, respectively.

The inbound stream peak hour traffic volume increased from 108 to 598 Veh/h during the AM peak period and from 196 to 414 Veh/h during the PM peak period for 2007 and 2010, respectively. The major increase in traffic volumes was as a result of the school, offices and the retail development. A slight increase on the PHF was experienced during the AM and PM peak periods. This implies that there was an improvement in the evenness of the peak hour traffic volumes distribution. The peak hour changed from 07:45 – 08:45 to 07:00 – 08:00 and from 16:00 – 17:00 to 15:45 – 16:45 during the AM and PM peak periods, respectively.

Table 4: Nellmapius Drive and John Vorster Drive Intersection Results for the affected Approach

Peak Period			AM Peak	Morning	Midday	Afternoon	PM Peak
Peak Hour			06:00 to 09:00	09:00 to 12:00	12:00 to 14:00	14:00 to 15:30	15:30 to 18:00
South-Eastern Approach 2007	Outbound traffic flow	PHV	126	194	291	260	377
		15-Min Vol.	39	60	84	77	108
		PHF	0.81	0.81	0.87	0.84	0.87
		Peak Hour	08:00 to 09:00	10:45 to 11:45	12:30 to 13:30	14:30 to 15:30	16:45 to 17:45
	Inbound traffic flow	PHV	108	145	165	165	196
		15-Min Vol.	33	48	47	53	58
		PHF	0.82	0.76	0.88	0.92	0.84
		Peak Hour	07:45 to 08:45	10:45 to 11:45	12:15 to 13:15	14:00 to 15:00	16:00 to 17:00
	Inbound Split (%)	PHV	46	43	36	39	34
South-Eastern Approach 2010	Outbound traffic flow	PHV	553	386	494	532	486
		15-Min Vol.	228	116	130	181	150
		PHF	0.61	0.83	0.95	0.73	0.81
		Peak Hour	07:15 to 08:15	11:00 to 12:00	12:30 to 13:30	14:15 to 15:15	15:30 to 16:30
	Inbound traffic flow	PHV	598	348	449	399	414
		15-Min Vol.	170	100	139	113	118
		PHF	0.88	0.86	0.81	0.88	0.88
		Peak Hour	07:00 to 08:00	11:00 to 12:00	12:45 to 13:45	14:00 to 15:00	15:45 to 16:45
	Inbound Split (%)	PHV	52	47	48	43	46

Figures 25 and 26 show the variation in peak hourly traffic volumes for inbound and outbound traffic streams during the peak periods. It shows that there was an increase of over 50% for the inbound traffic stream. The two Figures show that there was an increase in peak hour traffic volumes from 2007 to 2010 due to new land development trips. This implies that a change in land-use and extension of development can negatively affect and change the existing traffic conditions at an intersection.

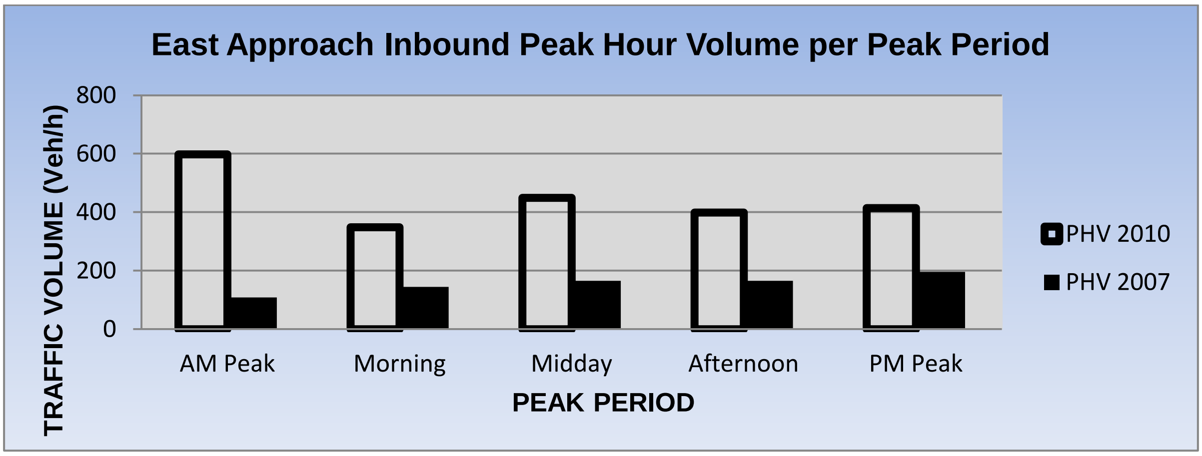


Figure 25: Nellmapius and John Vorster Drive Intersection Inbound Traffic PHV

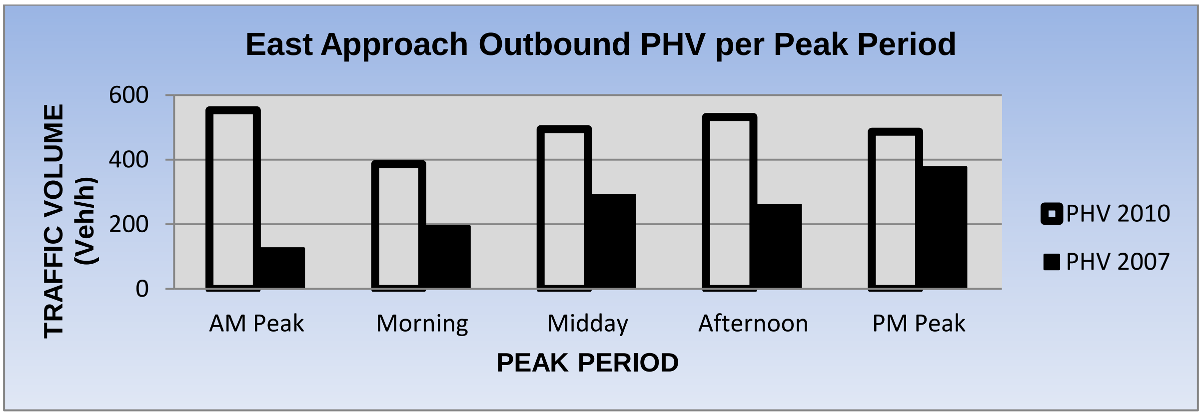


Figure 26: Nellmapius and John Vorster Drive Intersection Outbound Traffic PHV

Figures 27 and 28 show the PHF variation for inbound and outbound traffic stream during the peak periods at the affected approach. The variation was as a result of additional traffic volumes generated and attracted by new developments. The inbound stream indicated uniformity in traffic flow distribution during the critical peak periods (the AM and PM peak). The outbound traffic stream during the AM peak had a major drop of the PHF (from 0.81 to 0.61) and PHF values of more than 0.80 during the PM peak period. The drop on the AM peak PHF can be attributed to more traffic volume that is concentrated during a single 15-min peak with less traffic volumes during the other three 15-min during a peak hour. The PM peak stability can be attributed to traffic volumes distributed evenly during an hour. The following factors might contribute to the stability of the PHF at an intersection:

a) A proportion of the previously expected vehicular trips from the affected approach were absorbed by working opportunities created by the new developments;
b) Bulk of the trips could be concentrated to a specific 15 minute peak during the peak hour;
c) The operational times of different land-use types;
d) An accident in the vicinity of the intersection and
e) Road maintenance in the vicinity

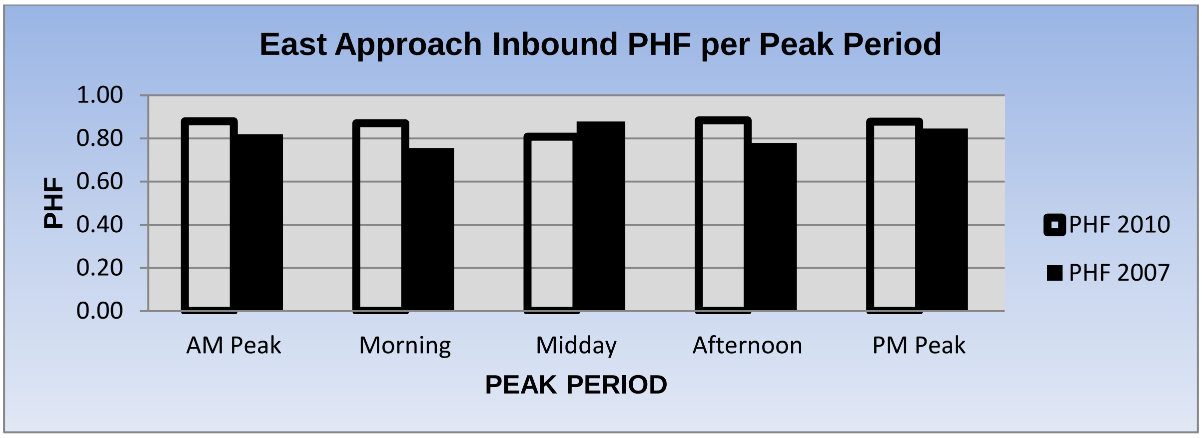


Figure 27: Nellmapius and John Vorster Drive Intersection Inbound PHF

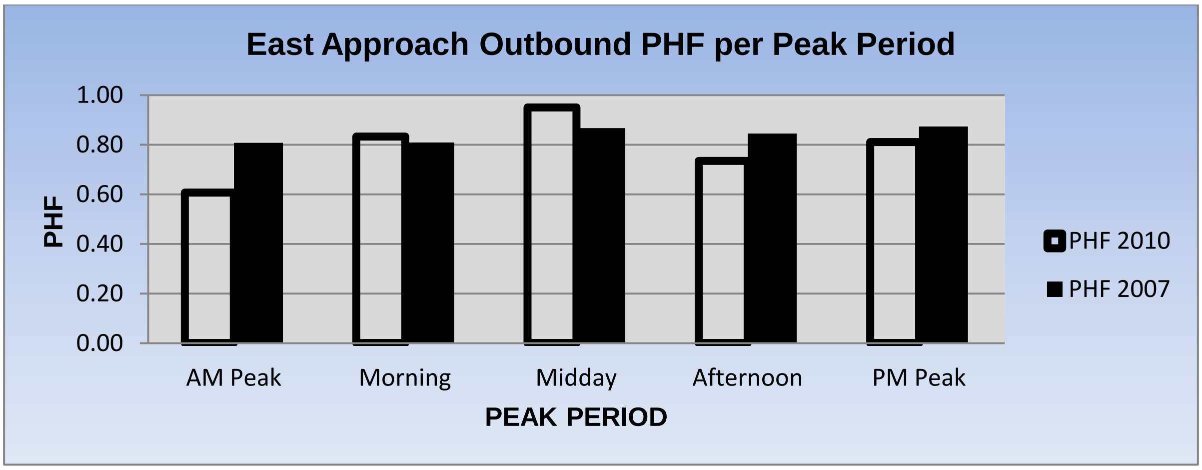


Figure 28: Nellmapius and John Vorster Drive Intersection Outbound PHF

Figure 29 shows the directional split at the affected approach for 2007 and 2010. The inbound traffic stream experienced an increase in traffic volumes after completion of land development. The percentage split between the inbound and the outbound traffic stream for both 2007 and 2010 indicates that the outbound stream carried more traffic volumes. However, there was an increase at the inbound stream during year 2010 due to land-uses that could attract traffic from the east of the intersection. The land-use types included a school, offices and a retail complex.

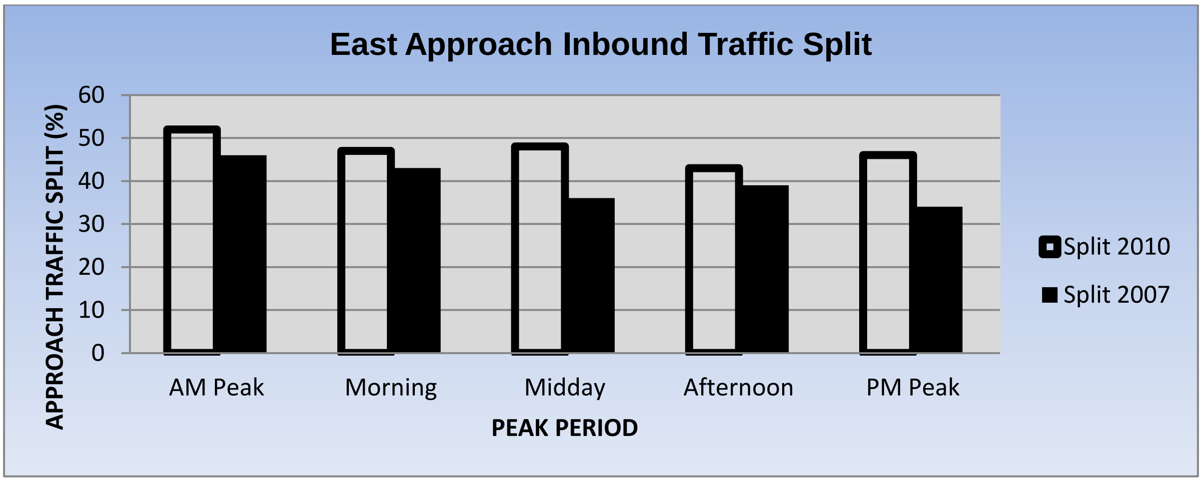


Figure 29: Nellmapius and John Vorster Drive Intersection Traffic Split

Based on the above analysis, it can be concluded that:

a) Developments with its major traffic volumes subjected to one intersection approach for access indicated substantial increases in peak hour traffic volumes.

b) The stability of the PHF was minimally affected due to land-use change and growth in land development focused at a single intersection approach. Mix land-uses also contributed to the slight instability of the PHF. Different land-uses had different peak periods which influenced the traffic flow distribution at the affected approach. The variability depended on the traffic flow distribution encouraged by a particular land-use type after land-use change.

c) An increase in traffic volumes at both the inbound and outbound approach streams during the different peak periods as a result of land-use change and growth in land development was experienced. The directional split difference at the affected approach was influenced by the type of land-use.

b. Scenario 2

Scenario 1 as discussed in sub-section 4.2(a) represented intersections that gain access from one intersection whereas scenario 2 represents the intersections where access to a development could be gained from two or more intersections on the road network. Zambesi and Breed-Visvanger Street Intersection was used to discuss scenario 2 as shown in Figure 30. Similar behavioural patterns at other selected intersections were noted. They included Atterbury Drive and Manitoba-Alsatian Street, and Simon Vermooten Drive and Lynnwood Road intersections.

Zambesi Drive is an east-west major arterial class 3 route that links Lavender Drive from the west with N1 national route in the east. The road carries high traffic volumes during the peak periods. Breed and Visvanger Streets are class 4 routes providing access to mixed land-use developments in the north and south of the intersection. The intersection was upgraded to accommodate additional development trips (Figure14 and 15).

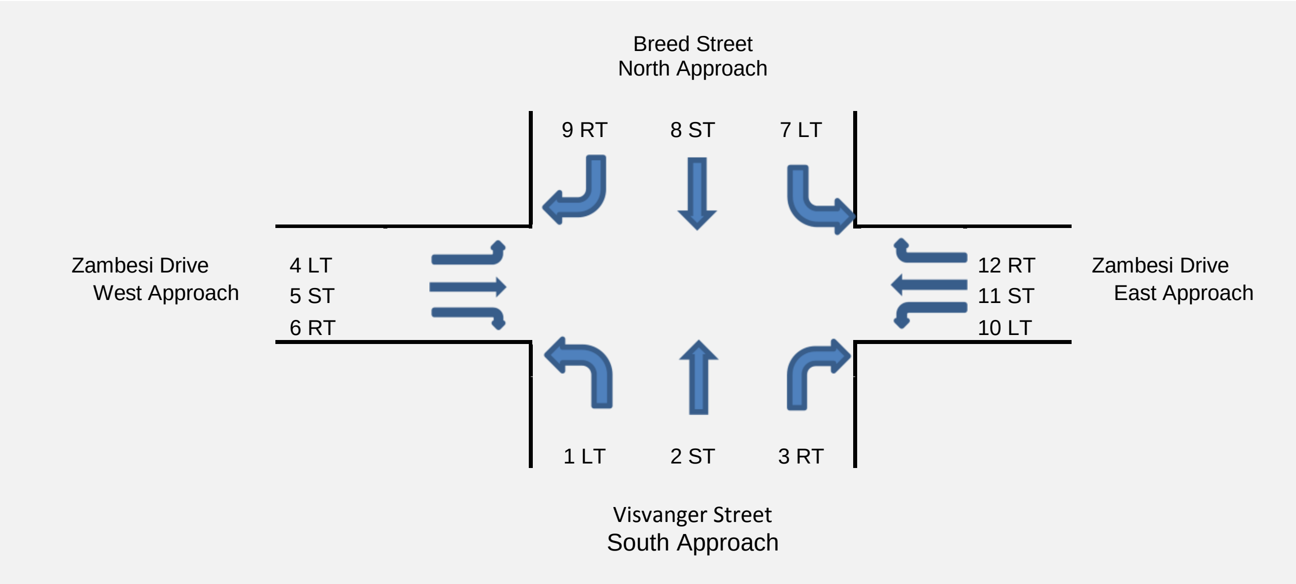


Figure 30: Zambesi Drive and Visvanger / Breed Street Intersection Turning Movements

where:

RT = Right Turning movement

ST = Straight Through movement

LT = Left Turning movement

The North approach was represented by traffic movement 2-ST, 4LT and 12RT for the inbound stream and 7-LT, 8-ST and 9-RT for the inbound stream. Traffic counts at the intersection were conducted in years 2005 and 2008.

Table 5 shows the results obtained at the affected North approach of the intersection. New developments north of the intersection consisted of motor dealerships, retail centre and residential developments. Due to the nature of these developments, traffic flow distribution was affected because of different peak periods associated with each development. The outbound stream during the AM peak period experienced a decrease in peak hour traffic volume from 553 to 482 Veh/h while the PM peak period increased from 516 to 798 Veh/h.

A similar pattern was also experienced on the PHF during the critical peak periods, AM and PM peak periods. The AM peak period had a decrease from 0.91 to 0.79 while the PM peak period had an increase from 0.89 to 0.98 of PHF. This could also be attributed to the types of land-uses north of the intersection. The directional split at the approach showed that outbound stream carried high traffic volumes.

The inbound stream experienced minimal increase in traffic volumes during the AM and PM peak periods. This was due to traffic diverting to other nearby streets to access the new developments avoiding the already congested main road, Zambesi Drive. The AM and PM peak periods increased from 305 to 311 Veh/h and from 475 to 535 Veh/h, respectively.

Major variations on PHF due to traffic diversion at the inbound stream were experienced. PHF varied from 0.87 to 0.80 and from 0.85 to 0.94 during the AM and PM peak periods. This meant that the AM peak traffic flow was not evenly distributed whereas the PM peak traffic flow was evenly distributed during the peak hour.

Table 5: Zambesi Drive and Visvanger-Breed Street Intersection Results for the Affected Approach

Peak Period			AM Peak	Morning	Midday	Afternoon	PM Peak
Peak Hour			06:00 to 09:00	09:00 to 12:00	12:00 to 14:00	14:00 to 15:30	15:30 to 18:00
North Approach 2005	Outbound traffic flow	PHV	553	286	229	329	516
		15-Min Vol.	152	77	65	92	145
		PHF	0.91	0.93	0.88	0.89	0.89
		Peak Hour	06:30 to 07:30	09:30 to 10:30	13:00 to 14:00	14:30 to 15:30	16:15 to 17:15
	Inbound traffic flow	PHV	305	247	255	293	475
		15-Min Vol.	88	65	74	81	139
		PHF	0.87	0.95	0.86	0.90	0.85
		Peak Hour	07:30 to 08:30	09:45 to 10:45	12:30 to 13:30	14:30 to 15:30	16:30 to 17:30
	Inbound Split (%)	PHV	36	46	53	47	48
North Approach 2008	Outbound traffic flow	PHV	482	498	590	612	798
		15-Min Vol.	153	146	177	184	204
		PHF	0.79	0.85	0.83	0.83	0.98
		Peak Hour	08:00 to 09:00	10:15 to 11:15	13:00 to 14:00	14:15 to 15:15	16:30 to 17:30
	Inbound traffic flow	PHV	311	331	423	425	535
		15-Min Vol.	97	99	133	112	142
		PHF	0.80	0.84	0.80	0.95	0.94
		Peak Hour	07:15 to 08:15	11:00 to 12:00	13:00 to 14:00	14:30 to 15:30	15:30 to 16:30
	Inbound Split (%)	PHV	39	40	42	41	40

As discussed, traffic growth was extensively experienced during the PM peak periods at the outbound stream as shown in Figures 31. This can be attributed to retail developments which generate high traffic volumes during the PM peak periods.

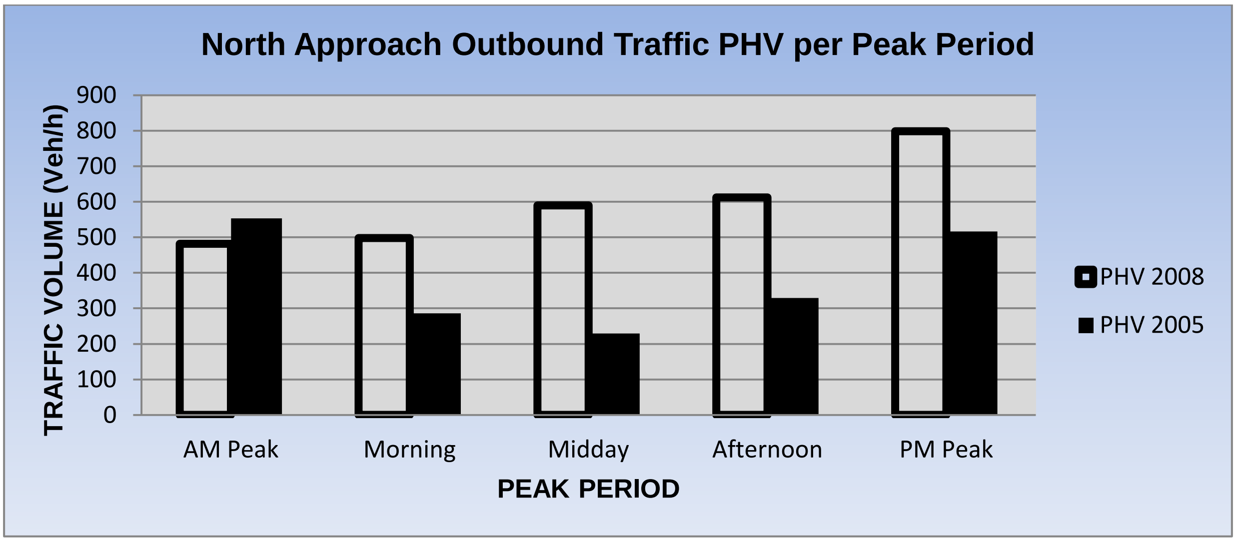


Figure 31: Outbound Zambesi Drive and Visvanger-Breed Street Intersection PHV per Peak Period.

The inbound stream experienced minimal growth in traffic volume as shown in Figure 31. The traffic growth due to new development could be diverted to nearby intersection avoiding the congested main road.

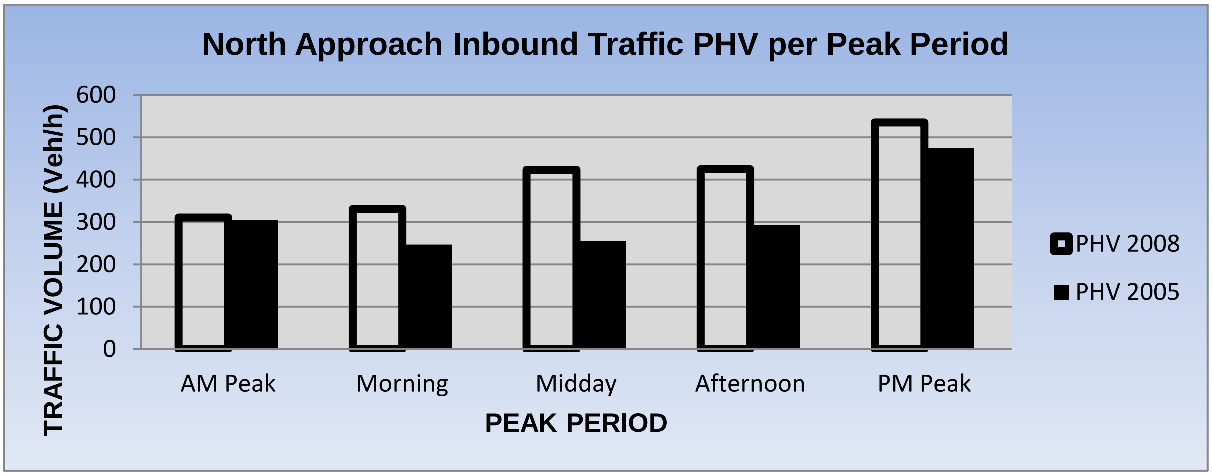


Figure 32: Inbound Zambesi Drive and Visvanger-Breed Street Intersection PHV per Peak Period

Figures 32 and 33 show the PHF variability at the affected approach. Variations on the PHF were experienced during the critical peak periods, AM and PM peak periods. The inbound stream experienced major variations on PHF due to traffic diversion from the main road, Zambesi Drive. This showed that sufficient accessibility to any land-use type could affect the traffic patterns at an intersection thus influencing the PHF stability.

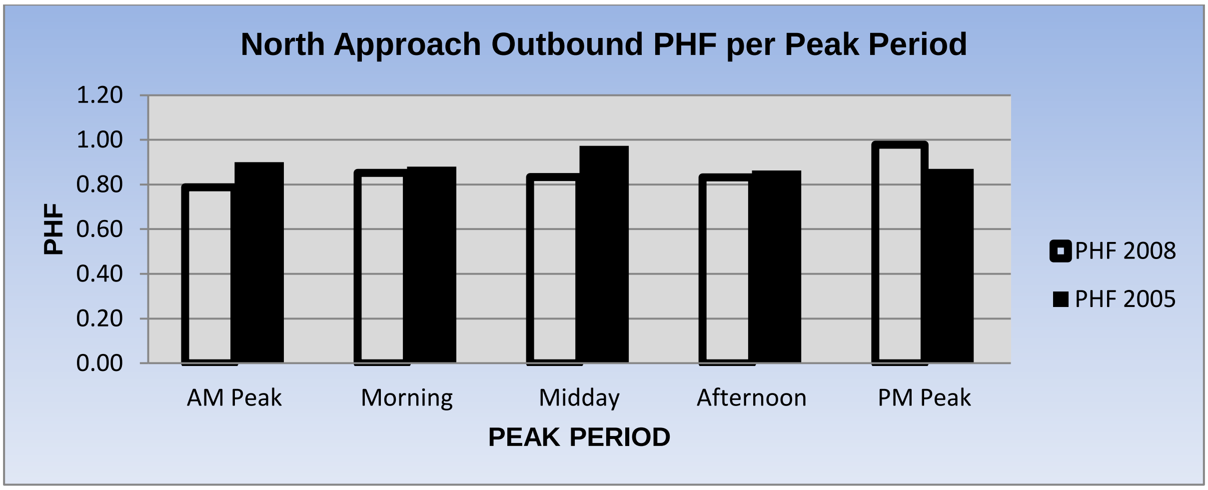


Figure 33: Outbound Zambesi Drive and Visvanger-Breed Street Intersection PHF per Peak Period

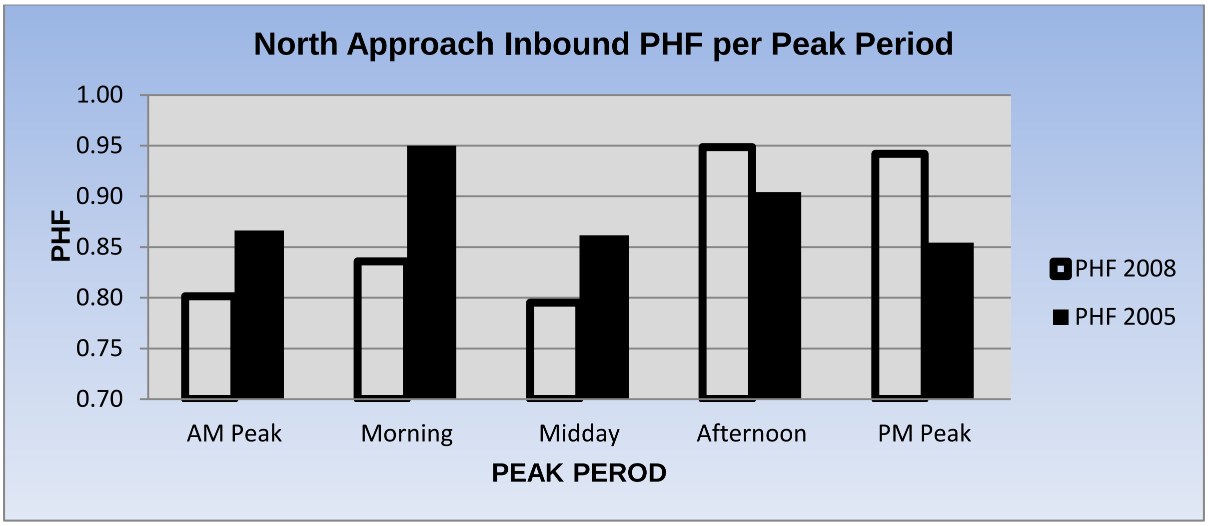


Figure 34: Inbound Zambesi Drive and Visvanger-Breed Street Intersection PHF per Peak Period

Based on the above analysis, it can be concluded that:

a) Developments that gained access from other intersections in the vicinity showed minimal growth on the peak hour traffic volumes. Development trips could be diverted to other intersections closer to the development avoiding the congested intersection along major routes like the Zambesi Drive.

b) The PHF indicated major variations due to diverted traffic volumes to other street in the vicinity for access to developments. This can be attributed to the remaining traffic volumes being focused to a particular 15-min peak within a peak hour. Road improvements could also contribute where traffic volumes clear quickly due to sufficient capacity at an intersection.

As demonstrated, land-use change could affect the existing PHF at an intersection as well as the traffic flow. The PHF variation differs from intersection to intersection and from day to day as a result of the land-uses in the vicinity and traffic conditions on the road system. The variability of the PHF shows the importance of producing local default values that could be used during traffic analysis for a particular land-use type. To assist in selecting the appropriate locations to predict such default values, an intersection approach which is the main access to a land-use should be used. Chapter 5 aims at predicting PHF relating to a specific land-use type.

CHAPTER 5 – COMPUTATION OF PHF AT SELECTED LAND-USES

5.1 Traffic data analysis to predict PHF per land-use

Land-uses that were frequently established and those having an impact on the day-to-day traffic operations on the road network were identified. The land-uses identified for analyses were residential; offices; industrial; institutional: schools; retail; medical: hospitals and places of worship. For each land-use, intersections located in the vicinity or located in such a way that they were able to clearly produce realistic PHF values were used. The traffic data from intersection approaches to and from the land-uses were used to predict the appropriate PHF values. Where traffic counts data were not readily available, new traffic counts were conducted.

The overall results for each land-use obtained from the spreadsheet prepared for this purpose were tabulated. The STATA data analysis and statistics software was used to further analyse the tabulated results where tables and figures were produced to assist with the final analysis. An example of the results produced by the STATA data analysis and statistics software is shown in Appendix C. Design chart in a table format showing the produced PHF values for each land-use type was developed. The design chart also indicated the most critical peak hours to be considered during traffic analysis. The results as obtained from each land-use consisted of residential, office, industrial, institutional, retail and medical types.

a. Residential developments

Table 6 shows the results of the intersections selected to predict the PHF for residential developments. Nine intersections were identified and selected for analysis. The critical AM and PM peak periods traffic volumes were used to predict the possible PHF value to be associated with residential developments. Traffic counts at residential developments with different livelihood standards were obtained. Different livelihood standards come as a result of the different types of residential developments. These types could include single dwelling, apartments and flats, simplexes and duplexes, multi-level townhouses and retirement villages.

Table 6: Selected Intersections Results Representing Residential Developments

Residential		Peak Period	Development Inbound and Outbound				
Intersection	Approach		Peak Hour	PHV	15-min PV	PHF	Inbound Split (%)
Church Street and Strachan Street	North	06:00 to 09:00	06:30 to 07:30	1846	475	0.97	18
		15:30 to 18:00	16:45 to 17:45	904	242	0.93	63
Zambesi Drive and Zambesi Estate Street	North	06:00 to 09:00	06:45 to 07:45	350	98	0.89	40
		15:30 to 18:00	16:00 to 17:00	332	94	0.88	53
Brits Road and Doreen Avenue	South	06:00 to 09:00	06:30 to 07:30	266	78	0.85	38
		15:30 to 18:00	15:45 to 16:45	267	74	0.90	57
Hebron Road and Umphafa Street	South	06:00 to 09:00	06:00 to 07:00	719	210	0.86	36
		15:30 to 18:00	16:15 to 17:15	765	210	0.91	63
	North	06:00 to 09:00	06:00 to 07:00	283	108	0.66	35
		15:30 to 18:00	16:15 to 17:15	176	55	0.80	68
Cura Avenue and Stellenberg Road	North	06:00 to 09:00	06:45 to 07:45	252	84	0.75	15
		15:30 to 18:00	16:30 to 17:30	168	49	0.86	71
Stonewall Boulevard and Old Farm Road	North	06:00 to 09:00	07:00 to 08:00	447	129	0.87	21
		15:30 to 18:00	16:45 to 17:45	584	177	0.83	69
Old Farm Road and Hans Strijdom Drive	East	06:00 to 09:00	07:00 to 08:00	1531	435	0.88	29
		15:30 to 18:00	16:00 to 17:00	1561	423	0.92	52
Witch Hazel Avenue and Eco-park Boulevard	South	06:00 to 09:00	07:00 to 08:00	402	113	0.89	12
		15:30 to 18:00	17:00 to 18:00	445	138	0.81	62
John Vorster and Karee Street	East	06:00 to 09:00	07;00 to 08:00	218	63	0.86	24
		15:30 to 18:00	16:45 to 17:45	208	65	0.80	60

On the basis of the data in Table 6, the summary of the computed minimum, maximum average and standard deviation of the traffic Peak Hour Volume (PHV), the 15-min traffic Peak Volume and the Peak Hour Factor (PHF) results are presented in Table 7. From the twenty observations, a low PHF standard deviation of 0.069 was found. This implies that the values obtained are very close to the average PHF of 0.86. A low standard deviation indicates that the data points tend to be very close to the average, whereas high standard deviation indicates that the data points are spread out over a large range of values. The PHF ranged between 0.66 and 0.97 during both the AM and PM peak periods. As a result, it shows that at any given time while conducting traffic counts, any value of the PHF within the range indicated could be obtained and be used in traffic analysis. Any PHF value used in traffic analysis could have an impact on the final results. Different conditions on the road network in a particular day could affect the intersection operation, thereby producing unrealistic results. The defaults values, 0.92 and 0.95, normally used in traffic analysis fall within the ranged obtained.

The minimum and the maximum Peak Hour Traffic Volume were found to be 168 and 1846 Veh/h , respectively. The average of 584 Veh/h showed that residential developments carried high traffic volumes during the peak periods. With such a huge difference between the minimum and the maximum peak hour volumes, any PHF could be produced.

Table 7: Summary of Residential Development Results

Variable	Min PHF	Max PHF	Average	Std. Dev.
PHV	168	1846	584	503
15-Min Vol.	49	475	166	132
PHF	0.66	0.97	0.86	0.069

The spread of PHF in relation to the peak hour traffic volume and the peak 15-min traffic volume obtained in Table 6 was illustrated as shown in Figure 35. It showed that the PHF ranged more between 0.80 and 1.00. This meant that residential development could generate evenly distributed traffic during the peak periods. However, different values could be obtained at any given day thus affecting the final design results of an intersection. Therefore, a default value to represent residential developments was required.

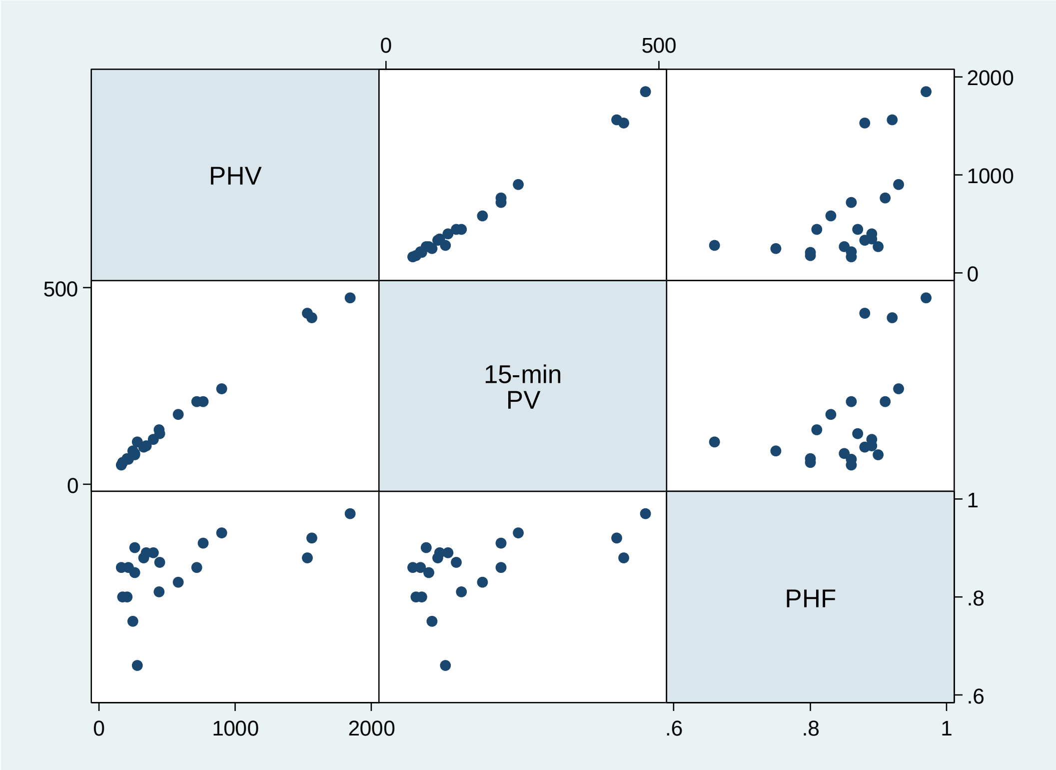


Figure 35: Relationship between PHF, PHV and 15-min Peak Volume at Residential Developments

The PHF obtained in Table 6 was summarized further as shown in Figure 36 to illustrate the PHF variation during the AM and PM peak periods. Minimal variations between the different peak periods were experienced. This can be attributed to the same activity of residing found at residential developments. However, with the range obtained, a single PHF value must be determined for traffic analysis purposes. Consistency and fairness could be improved during traffic analysis for design purposes.

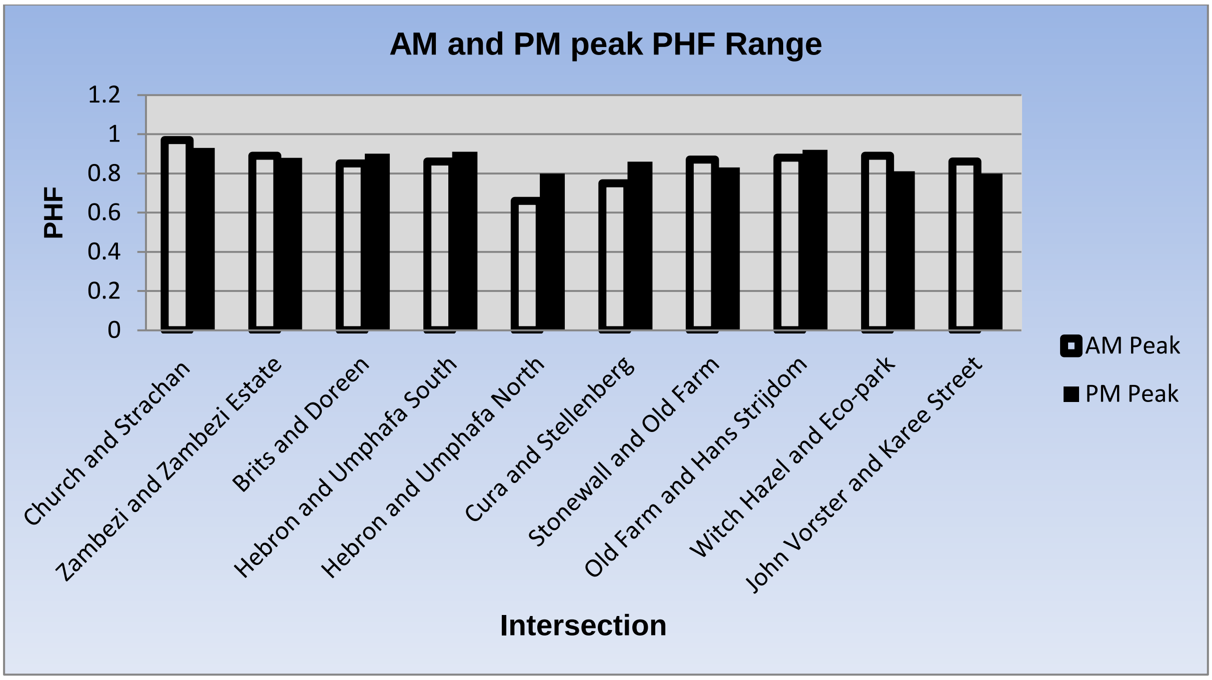


Figure 36: Residential AM and PM peak PHF Variation

The inbound directional split obtained in Table 6 was further summarized as shown in Figure 37. It shows the approach inbound directional split with the outbound stream during the AM and PM peak periods. The AM peak directional split indicates that fewer vehicles were entering the developments. As can be expected during the AM peak, higher traffic volumes will exit any residential development to different personal and business activities.

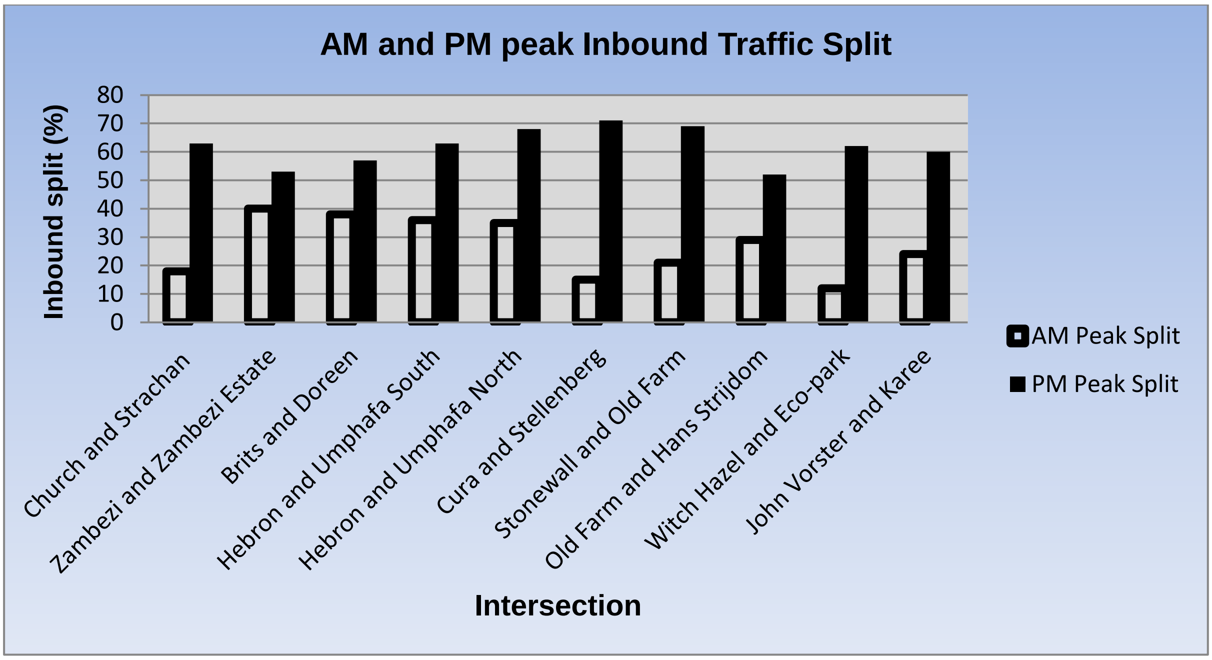


Figure 37: Residential AM and PM peak Traffic Split

Table 8 shows the PHF frequency from the twenty PHF values obtained in Table 6. It shows the frequency of the PHF obtained during the AM and PM peak periods. The results showed that the rate of occurrence of PHF was found to be at 0.86. This value was also equal to the average PHF value of 0.86 obtained. It was therefore concluded that the PHF of 0.86 must be considered during traffic analysis at residential developments.

Table 8: PHF Frequency at Residential Development

PHF	Frequency
0.66	1
0.75	1
0.80	2
0.81	1
0.83	1
0.85	1
0.86	3
0.87	1
0.88	2
0.89	2
0.90	1
0.91	1
0.92	1
0.93	1
0.97	1
Total	20

Table 9 shows the frequency of the peak hours and the PHF obtained during such peak hours computed in Table 6. The PHF and the inbound directional traffic split found were also indicated at the critical peak hours. The busiest peak hour during the AM and PM peak periods were found to be 07:00 to 08:00 and 16:45 to 17:45, respectively. Therefore, it is important that during traffic analysis the critical peak hours during the AM and PM peak periods indicated need to be considered. The closest directional split obtained was 70% and 30% at the inbound and outbound stream during the AM peak period.

Table 9: Residential Peak Hour Frequency

Peak Hour	Frequency	PHF				Inbound Traffic Split (%)			
06:00 to 07:00	2	0.66	0.86						
06:15 to 07:15	2	0.80	0.91						
06:30 to 07:30	2	0.85	0.97						
06:45 to 07:45	2	0.75	0.89						
07:00 to 08:00	4	0.86	0.87	0.88	0.89	12	21	24	29
15:45 to 16:45	1	0.90							
16:00 to 17:00	2	0.88	0.92						
16:30 to 17:30	1	0.86							
16:45 to 17:45	3	0.80	0.83	0.93		60	63	69	
17:00 to 18:00	1	0.81							

b. Office Developments

Office developments could be categorized as offices; home offices and undertakings; medical consulting rooms; research centres; conference centres. Table 10 shows the six (6) intersections that were selected to predict the PHF that could be used during traffic analysis for office developments. The critical AM and PM peak periods traffic volumes were used to predict the possible PHF value.

Table 10: Selected Intersections Results Representing Office Developments

Offices			Development Inbound and Outbound				
Intersection	Approach	Peak Period	Peak Hour	PHV	15-min PV	PHF	Inbound Split (%)
Meiring Naude Drive and Quitin Brand Street	West	06:00 to 09:00	07:15 to 08:15	702	198	0.89	88
		15:30 to 18:00	16:15 to 17:15	620	179	0.86	23
Witch Hazel Avenue and Eco-park Boulevard	West	06:00 to 09:00	07:15 to 08:15	473	129	0.92	55
		15:30 to 18:00	16:00 to 17:00	503	149	0.84	39
Meiring Naude Drive and CSIR Access	East	06:00 to 09:00	07:45 to 08:45	732	201	0.91	84
		15:30 to 18:00	16:00 to 17 :00	572	159	0.90	21
Matroosberg Street and River Walk	East	06:00 to 09:00	07:30 to 08:30	428	114	0.94	93
		15:30 to 18:00	16:00 to 17:00	425	126	0.84	2
Soutpansberg Road and OR Tambo Offices	South	06:00 to 09:00	07:30 to 08:30	495	163	0.76	82
		15:30 to 18:00	16:00 to 17:00	565	164	0.86	7
Meiring Naude Drive and Hotel Street	West	06:00 to 09:00	07:30 to 08:30	550	166	0.83	70
		15:30 to 18:00	16:15 to 17:15	474	133	0.89	21
	East	06:00 to 09:00	07:45 to 08:45	561	201	0.70	82
		15:30 to 18:00	16:00 to 17:00	369	104	0.89	36

On the basis of the data in Table 10, the summary of the computed minimum, maximum, average and standard deviation of the traffic Peak Hour Volume (PHV), the 15-min traffic Peak Volume and the Peak Hour Factor (PHF) results are presented in Table 11. A low PHF standard deviation of 0.064 out of the fourteen observations was found. The PHF average for office developments was found to be 0.86, where the minimum and the maximum values were 0.70 and 0.94, respectively. This implies that any value between the minimum and maximum PHF values could be found and be used for traffic analysis. From the 14 observations analysed, the peak hour traffic volume average was found to be 534 Veh/h.

Table 11: Summary of Office Development Results

Variable	Min PHF	Max PHF	Average	Std. Dev.
PHV	369	732	534	103
15-Min Vol.	104	201	156	32
PHF	0.70	0.94	0.86	0.064

The PHF spread in relation to the peak hour traffic volume and the 15-min peak traffic volume obtained in Table 10 is illustrated in Figure 38. It indicates where the PHF during particular peak hour traffic volume and a 15-min peak hour traffic volume occurred. The PHF was found to me more observed between 0.80 and 0.90. Therefore, a possible PHF for this type of land-use could be 0.80 and 0.90.

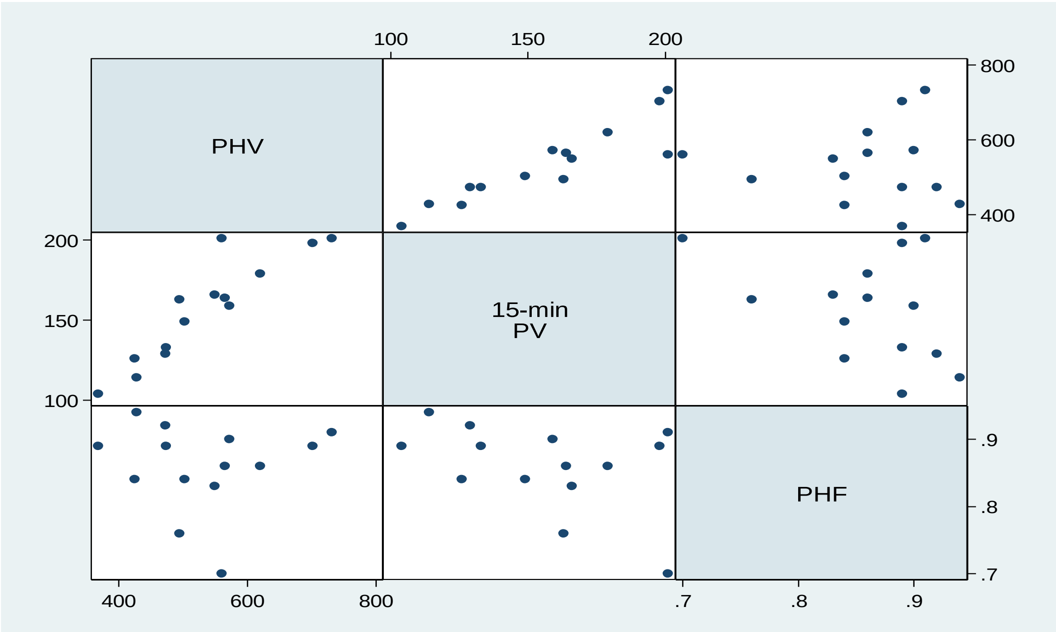


Figure 38: Relationship between PHF, PHV and 15-min Peak Volume at Office Developments

Figure 39 shows the PHF variability at office developments during the AM and PM peak periods obtained in Table 10. It shows that the PHF differ from intersection to intersection and from location to location as a result of varying traffic flow conditions.

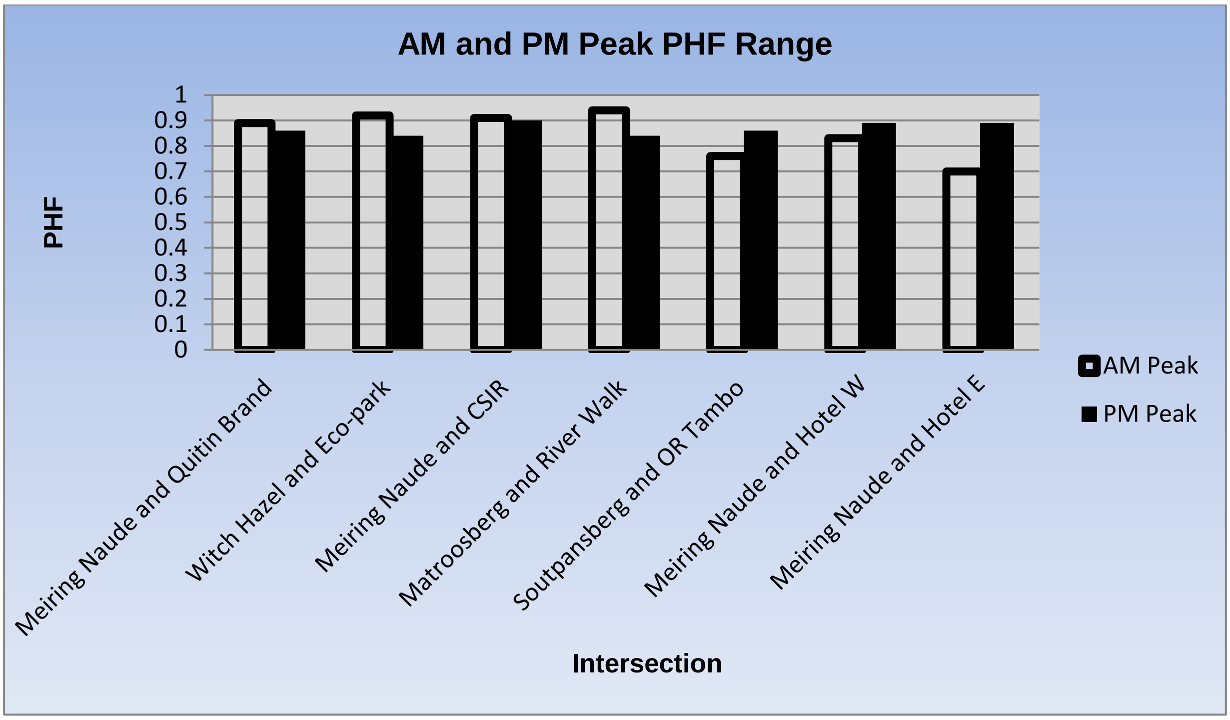


Figure 39: Office AM and PM peak PHF Variation

The traffic directional split at the affected intersection approach during the AM and PM peak periods obtained in Table 10 are illustrated in Figure 40. It shows the traffic directional split percentage between the inbound stream and the outbound stream. The AM peak period experienced higher traffic volumes entering the development and lower traffic volumes entering during the PM peak period. This can be attributed to office development being employment focused.

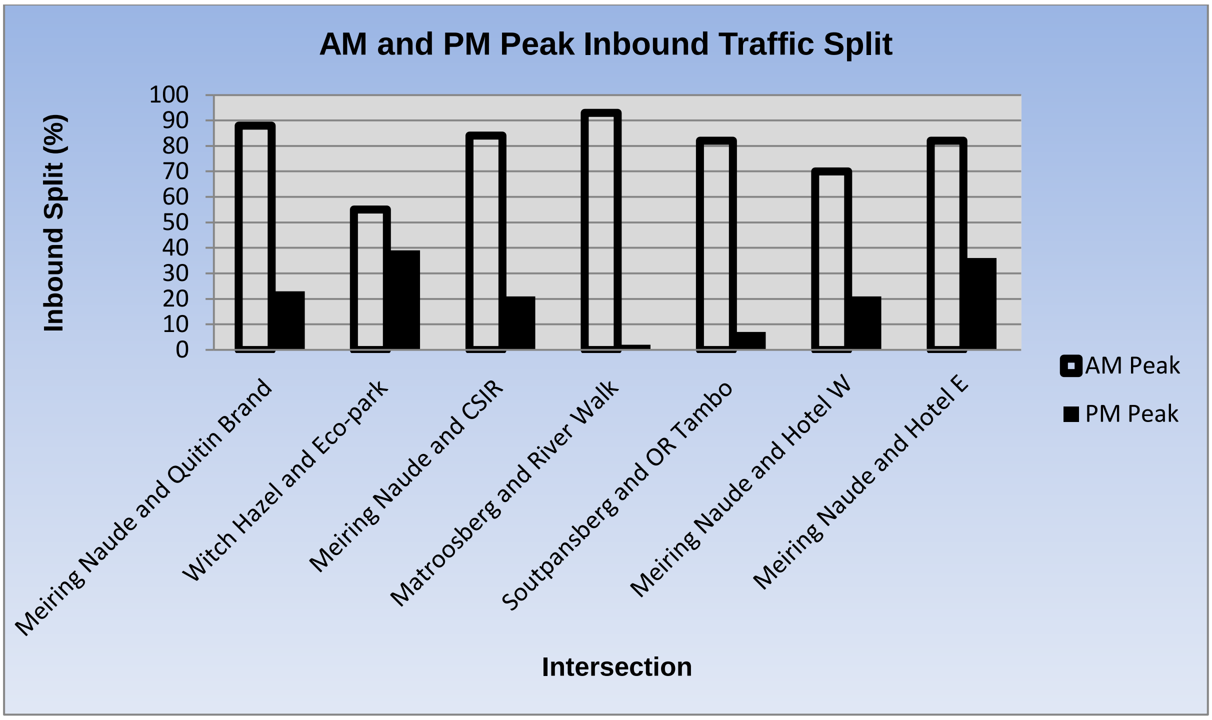


Figure 40: AM and PM peak Traffic Split at Office Developments

The PHF computed in Table 10 are shown in Table 12 to illustrate the frequency. It shows that the rate of occurrence of the PHF was found to be at 0.89 during the AM and PM peak periods. Based on this, it is therefore concluded that the PHF of 0.89 be considered during traffic analysis for office developments.

Table 12: Overall Office Development PHF Frequency Results

PHF	Frequency
0.70	1
0.76	1
0.83	1
0.84	2
0.86	2
0.89	3
0.90	1
0.91	1
0.92	1
0.94	1
Total	14

The peak hours at each peak hour traffic volume were computed in Table 10. Table 13 shows peak hours and the PHF obtained during such peak hours. This was to determine the critical peak hours during the AM and PM peak periods to be considered during traffic analysis. The peak hours 07:30 to 8:30 and 16:00 to 17:00

during the AM and PM peak periods, respectively should be considered the most critical hours for office developments. The inbound traffic splits during a critical peak hour were indicated. The purpose was to indicate the distribution in traffic flow at an intersection approach.

Table 13: Office Peak Hour Frequency

Peak Hour	Frequency	PHF					Inbound Traffic Split (%)				
07:15 to 08:15	2	0.89	0.92								
07:30 to 08:30	3	0.76	0.83	0.94			70	82	93		
07:45 to 08:45	2	0.70	0.91								
16:00 to 17:00	5	0.84	0.84	0.86	0.89	0.90	21	36	39	2	7
16:15 to 17:15	2	0.86	0.89								

c. Industrial Developments

Industrial developments are land-uses that include service industry, manufacturing, warehousing and distributions. Table 14 shows the results of the intersections selected to predict the appropriate PHF for industrial developments. Five intersections were selected for analysis. The AM and PM peak periods, as the critical peak periods for this type of land-use, were used to predict the appropriate PHF. The off-peak periods are mostly characterised by heavy vehicles due to deliveries, hence they were not presented.

Table 14: Selected Intersections Results Representing Industrial Developments

Industrial		Peak Period	Development Inbound and Outbound				
Intersection	Approach		Peak Hour	PHV	15-min PV	PHF	Inbound Split (%)
Waltloo Road and Kuit Street	West	06:00 to 09:00	07:00 to 08:00	211	66	0.80	82
		15:30 to 18:00	16:00 to 17:00	123	41	0.75	33
Pretoria Road and Fakkel Street	North	06:00 to 09:00	07:45 to 08:45	587	165	0.89	49
		15:30 to 18:00	16:15 to 17:15	652	177	0.92	49
R566 and Ernest Opperheimer Street	South	06:00 to 09:00	06:30 to 07:30	1311	557	0.59	80
		15:30 to 18:00	16:00 to 17:00	792	228	0.87	20
	North	06:00 to 09:00	06:15 to 07:15	795	261	0.76	57
		15:30 to 18:00	16:00 to 17:00	484	140	0.86	36
Dykor Street and Moreleta Street	West	06:00 to 09:00	06:45 to 07:45	514	146	0.88	56
		15:30 to 18:00	17:00 to 18:00	645	180	0.90	37
	East	06:00 to 09:00	07:15 to 08:15	916	256	0.90	56
		15:30 to 18:00	15:45 to 16:45	890	282	0.89	54
Voortrekker Road (R55) and Ellman Street	West	06:00 to 09:00	07:00 to 08:00	825	227	0.91	80
		15:30 to 18:00	16:15 to 17:15	895	254	0.88	22

On the basis of the data in Table 14, the summary of the computed minimum, maximum average and standard deviation of the traffic Peak Hour Volume (PHV), the 15-min traffic Peak Volume and the Peak Hour Factor (PHF) results are presented in Table 15. The PHF values obtained at the selected intersections were close to the average PHF of 0.84. This was illustrated by the standard deviation of 0.09 obtained, where the minimum and maximum PHF were 0.59 and 0.92, respectively. Any value obtained within the range could be used in traffic analysis and thereby affecting the final design results. The average peak hour traffic volume of 688 Veh/h shows that industrial developments generate high traffic volumes during the peak periods. The minimum and the maximum values of the peak hour traffic volume and the 15-min traffic volume could produce any PHF. As a result, a single PHF value to represent all industrial developments must be determined.

Table 15: Summary of Industrial Development Results

Variable	Mini PHF	Max PHF	Average	Std. Dev.
PHV	123	1311	688	303
15-Min Vol.	41	557	213	122
PHF	0.59	0.92	0.84	0.090

The PHF spread in relation to the traffic peak hour volume and the 15-min peak volume computed in Table 14 are illustrated in Figure 41. The PHF was observed to be stronger between 0.80 and 0.90 during both the AM and PM peak periods for industrial developments. The interesting thing noted is that the highest peak hour traffic volume of 1311 Veh/h gave the lowest PHF value of 0.59. This can be attributed to traffic flow being focused more on one 15-min within a particular peak hour and traffic conditions on the road network. Figure 41 should be viewed with Figure 42, which shows the variation of PHF at industrial developments.

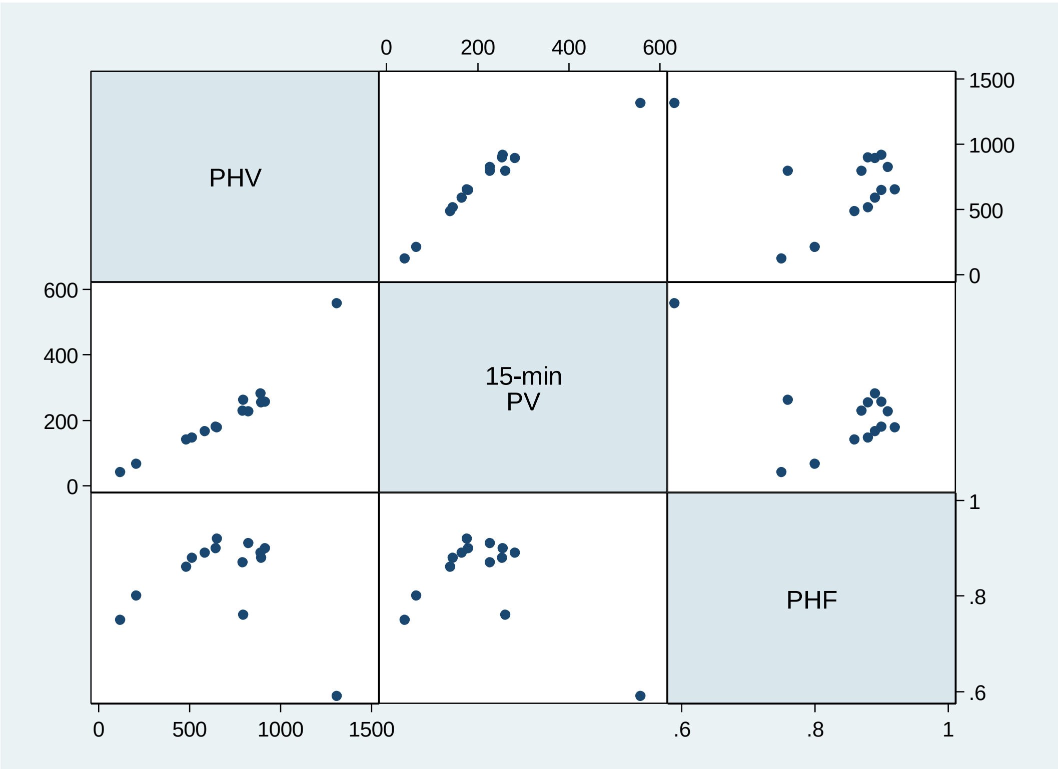


Figure 41: Relationship between PHF, PHV and 15-min Peak Volume at Industrial Developments

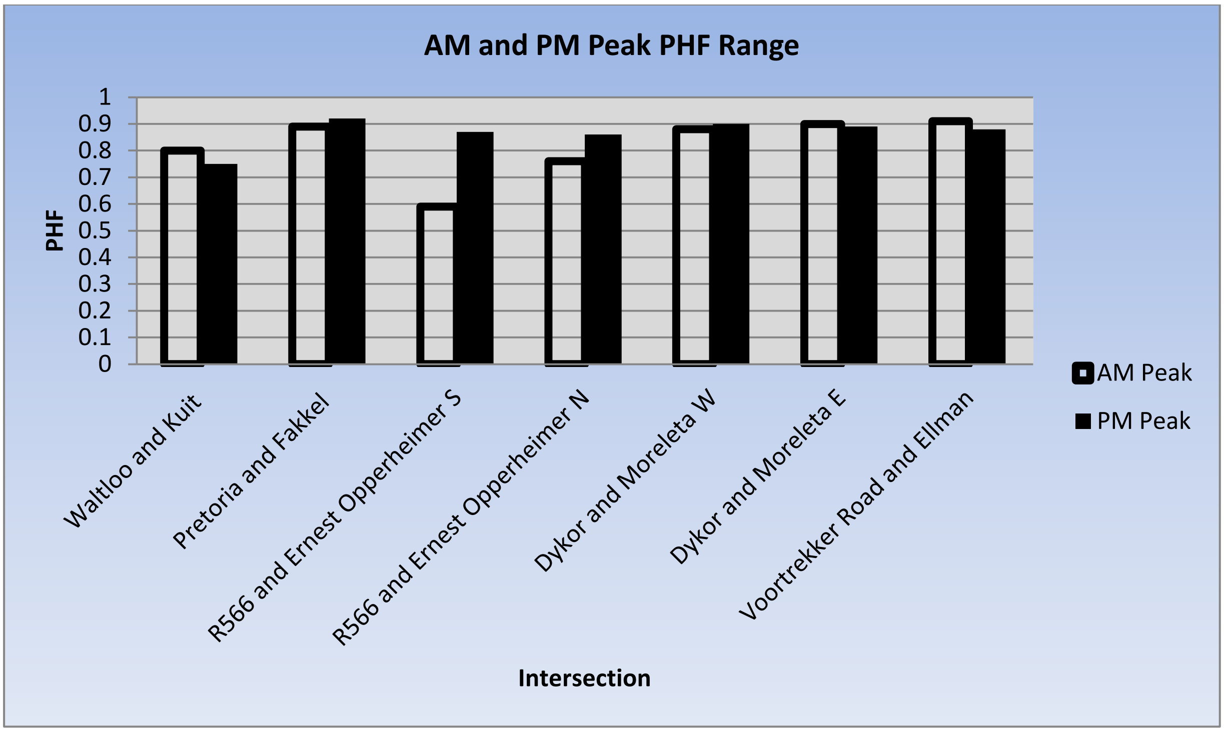


Figure 42: Industrial AM and PM peak PHF Range

Figure 43 shows the traffic flow directional split at the affected intersection approaches associated with industrial developments computed in Table 14. The results show that higher traffic volumes were experienced at the inbound stream during the AM peak hour and at the outbound stream during the PM peak hour. The same as office developments, industrial developments are classed as an employment sector.

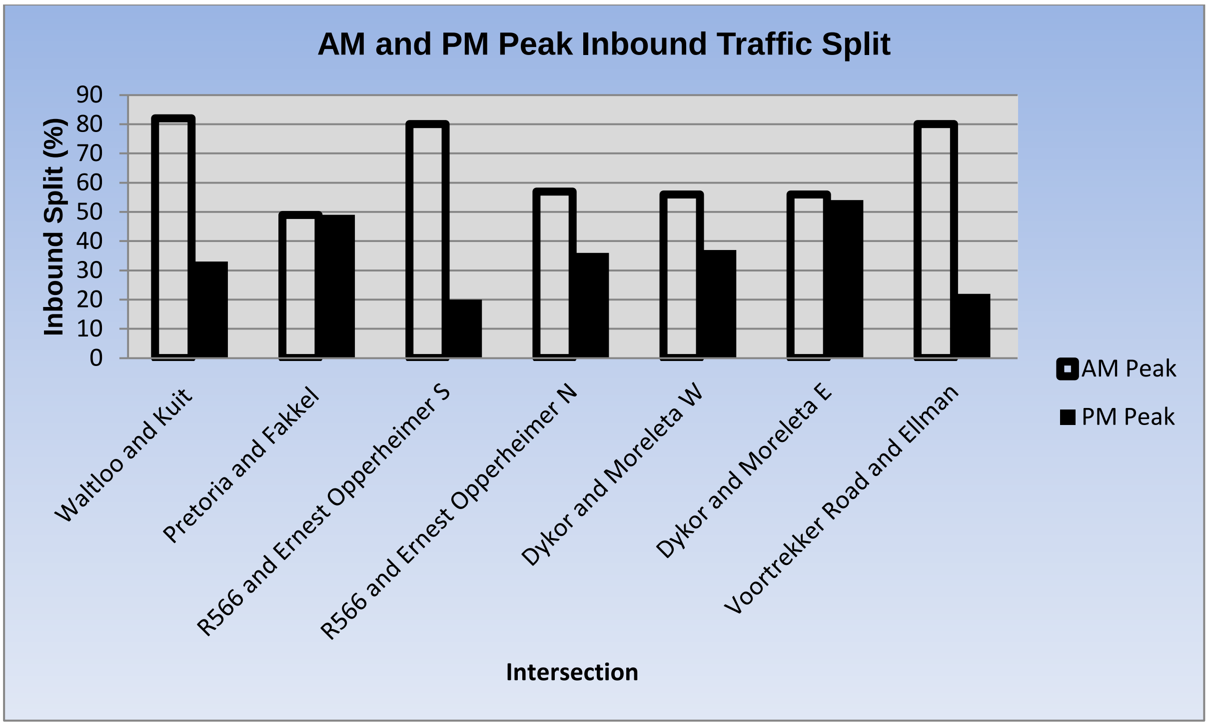


Figure 43: Industrial AM and PM peak Traffic Split

Table 16 shows the frequency of the PHF computed in Table 14. The rate of occurrence of the PHF was found to be at 0.88, 0.89 and 0.90. The average PHF of 0.84 obtained which was not equal to at least one of the three values obtained. The best possible way to arrive at the most appropriate PHF for industrial developments was to take the average of the three values which was found to be 0.89. Based on the above, it is therefore concluded that the PHF of 0.89 be considered during traffic analysis for industrial developments.

Table 16: Overall Industrial Development PHF Results

PHF	Frequency
0.59	1
0.75	1
0.76	1
0.80	1
0.86	1
0.87	1
0.88	2
0.89	2
0.90	2
0.91	1
0.92	1
Total	14

Based on the computed peak hour, Table 17 shows the peak hour that could be associated with industrial development in relation to the PHF. It shows that the 07:00 to 08:00 peak hour and the 16:00 to 17:00 peak hour during the AM and PM peak periods could be considered as the most critical peak hours during traffic analysis. The most likely directional split was found to be 80% and 20% at the inbound and outbound stream, respectively during the AM peak periods.

Table 17: Industrial Peak Hour Frequency

Peak Hour	Frequency	PHF			Inbound Traffic Split (%)		
06:15 to 07:15	1	0.76					
06:30 to 07:30	1	0.59					
06:45 to 07:45	1	0.88					
07:00 to 08:00	2	0.80	0.91		80	82	
07:15 to 08:15	1	0.90					
07:45 to 08:45	1	0.89					
15:45 to 16:45	1	0.89					
16:00 to 17:00	3	0.75	0.86	0.87	20	33	36
16:15 to 17:15	2	0.88	0.92				
17:00 to 18:00	1	0.90					

d. Institutional: Schools

Table 18 shows results from the intersections selected to predict the PHF for schools. Four intersections were selected for analysis. The AM, the Midday and Afternoon peak periods were used for analysis. This was based on the schooling hours at the primary schools in the vicinity of the selected intersections.

Table 18: Selected Intersections Results Representing Schools

School		Peak Period	Development Inbound and Outbound				
Intersection	Approach		Peak Hour	PHV	15-min PV	PHF	Inbound Split (%)
Boeing Street and Hans Strijdom Drive	North	06:00 to 09:00	06:45 to 07:45	1789	557	0.80	50
		12:00 to 14:00	13:00 to 14:00	632	262	0.60	40
		14:00 to 15:30	14:00 to 15:00	661	288	0.57	33
Soutpansberg Road and Wren Street	North	06:00 to 09:00	06:45 to 07:45	712	213	0.84	31
		12:00 to 14:00	13:00 to 14:00	323	96	0.84	43
		14:00 to 15:30	14:00 to 15:00	398	115	0.87	49
Daan de Wet Nel Drive and Rene Road	South	06:00 to 09:00	06:45 to 07:45	897	290	0.77	36
		12:00 to 14:00	13:00 to 14:00	220	79	0.70	45
		14:00 to 15:30	14:00 to 15:00	239	87	0.69	36
Anthesis Street and Cyme Crescent	South	06:00 to 09:00	06:45 to 07:45	270	83	0.81	31
		12:00 to 14:00	12:15 to 13:15	185	49	0.94	40
		14:00 to 15:30	14:15 to 15:15	147	44	0.84	50

On the basis of the data in Table 18, the summary of the computed minimum, maximum average and standard deviation of the traffic Peak Hour Volume (PHV), the 15-min traffic Peak Volume and the Peak Hour Factor (PHF) results are presented in Table 19. The PHF indicated a standard deviation of 0.111 from the twelve observations done. This implied that the PHF values obtained were fairly close to the average of 0.77. A wide range between the minimum and the maximum PHF of 0.57 and 0.94, respectively were obtained. The primary schools showed high traffic volume during the peak periods with an average of 539 Veh/h.

Table 19: Summary of School Results

Variable	Min PHF	Max PHF	Average	Std. Dev.
PHV	147	1789	539	462
15-Min Vol.	44	557	180	150
PHF	0.57	0.94	0.77	0.111

Figure 44 shows the PHF variation in relation to the peak hour traffic volume and the 15-min peak traffic volume obtained in Table 18. It shows scattered values of the PHF however fairly close to 0.80. The Figure shows that there is no stable PHF value that could be used for traffic analysis.

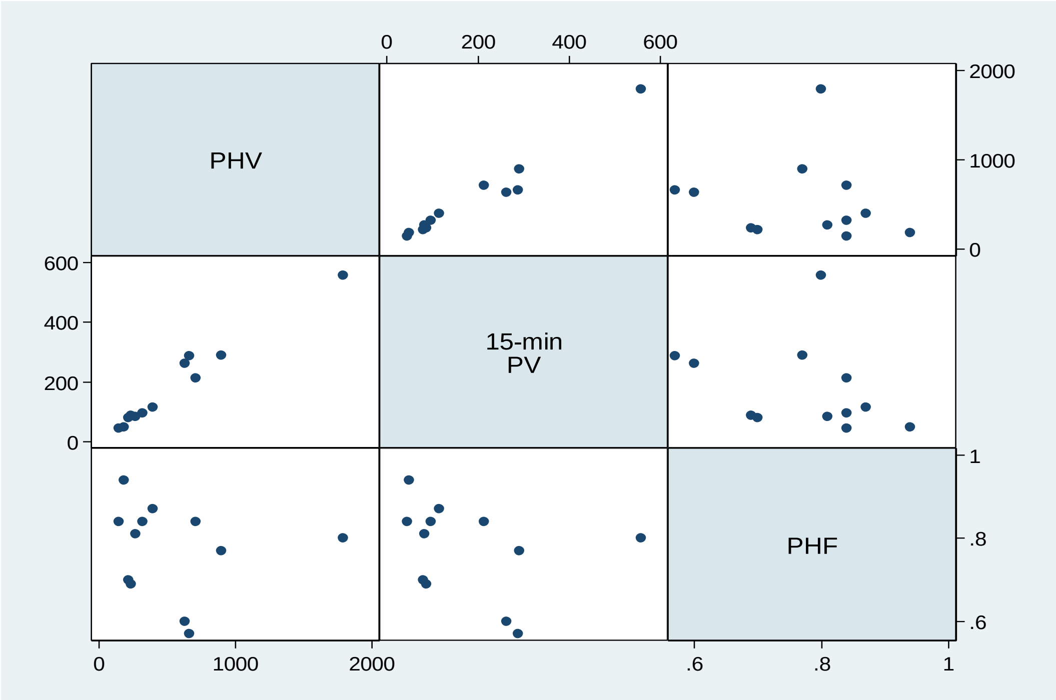


Figure 44: Relationship between PHF, PHV and 15-min Peak Volume at School

In support of Figure 44, Figure 45 shows the PHF variation at intersections in the vicinity of primary schools from the computed PHF in Table 18. It shows the variation between the selected peak periods for schools activities. With such a scattered range it is important to have a single PHF value to be used during traffic analysis at schools.

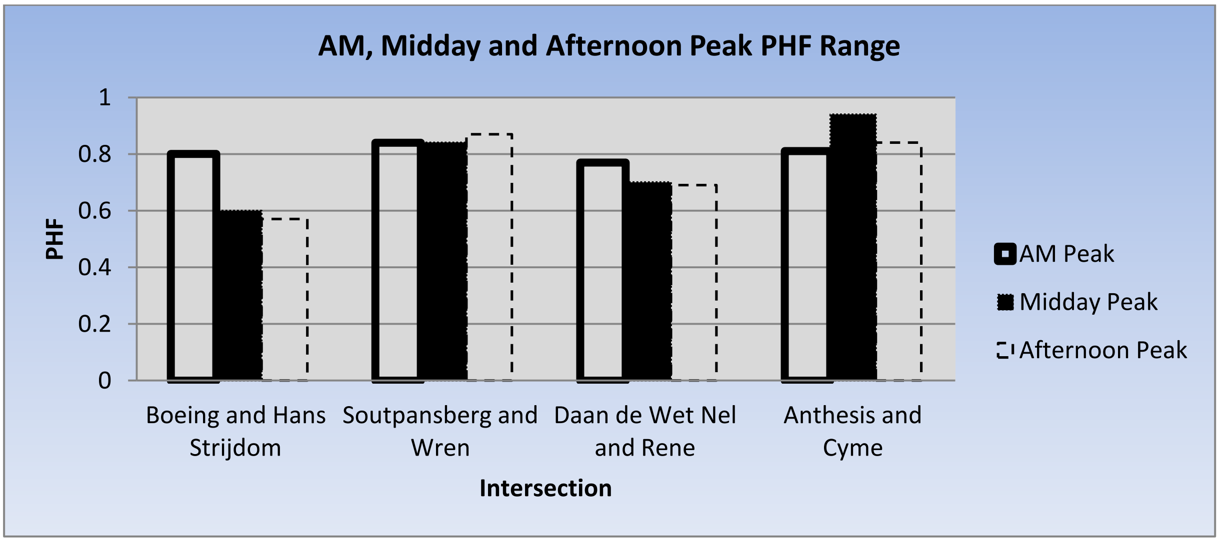


Figure 45: School AM and PM peak PHF Range

Travelling patterns at schools are characterised by dropping off of pupils. Figure 46 shows the directional split fairly close to each other from the computed inbound split in Table 18. This can be attributed to same trips going in and out of the school premises after dropping off scholars. The average inbound split during the selected peak periods was found to be close to 40%.

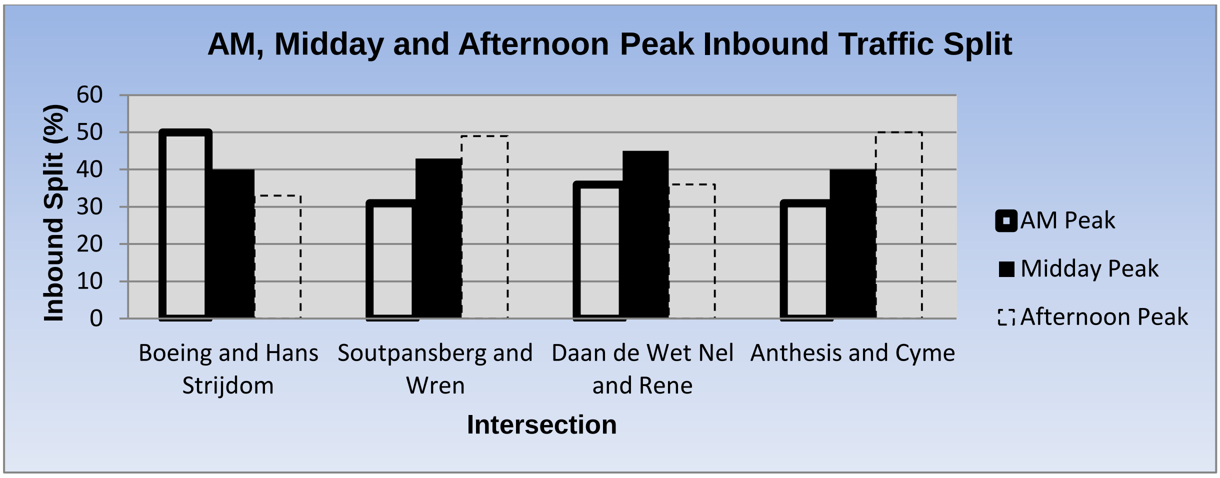


Figure 46: School AM and PM peak Traffic Split

Table 20 shows the PHF frequency at selected intersection computed in Table 18. The rate of occurrence of the PHF was found to be at 0.84 from the twelve observations done. It can therefore be concluded that the PHF of 0.84 should be considered when conducting traffic analysis for schools.

Table 20: Overall School PHF Frequency Results

PHF	Frequency
0.57	1
0.60	1
0.69	1
0.70	1
0.77	1
0.80	1
0.81	1
0.84	3
0.87	1
0.94	1
Total	12

The computed peak hours in Table 18 indicates that the peak hour to be considered during traffic analysis for this type of land-use is from 06:45 to 07:45 during the AM peak period as shown in Table 21. The AM peak is the most critical peak period at this land-use.

Table 21: School Peak Hour Frequency

Peak Hour	Frequency	PHF				Inbound Traffic Split (%)			
06:45 to 07:45	4	0.77	0.80	0.81	0.84	31	31	36	50
12:15 to 13:15	1	0.94							
13:00 to 14:00	3	0.60	0.70	0.84		40	43	45	
14:00 to 15:00	3	0.57	0.69	0.87		33	36	49	
14:15 to 15:15	1	0.84							

e. Retail Developments

Table 22 shows the results of the intersections selected to predict the PHF for retail developments. Four intersections in the vicinity of retail developments and providing access to such land-uses were selected for analysis. Saturday Morning, Midday and Afternoon peak periods were used for predict the appropriate PHF for retail development as well as the Friday PM peak periods traffic data. Retail developments include shopping centres; hardware and paint stores; motor dealerships; value retail; wholesale trades and building material stores.

Table 22: Selected Intersections Results Representing Retail Development

Retail Development		Peak Period	Development Inbound and Outbound				
Intersection	Approach		Peak Hour	PHV	15-min PV	PHF	Inbound Split (%)
Garstfontein Road and Philadelphia Avenue	North	09:00 to 12:00	09:45 to 10:45	2123	569	0.93	64
		12:00 to 14:00	13:00 to 14:00	2385	676	0.88	46
		14:00 to 15:30	14:30 to 15:30	1876	541	0.87	47
De Villa Bois Marueil Drive and Woodlake Boulevard	East	09:00 to 12:00	11:00 to 12:00	1748	527	0.83	58
		12:00 to 14:00	12:00 to 13:00	1554	415	0.94	48
		14:00 to 15:30	14:00 to 15:00	1347	338	1.00	47
Heinrich Drive and Madelief Avenue	West	09:00 to 12:00	10:00 to 11:00	650	175	0.93	50
		12:00 to 14:00	12:30 to 13:30	674	178	0.95	54
		14:00 to 15:30	14:15 to 15:15	624	184	0.85	53
	East	09:00 to 12:00	10:45 to 11:45	1360	386	0.88	61
		12:00 to 14:00	12:00 to 13:00	1348	375	0.90	66
		14:00 to 15:30	14:15 to 15:15	1318	353	0.93	60
Maphalla Drive and J Letwaba Street	West (Sat)	09:00 to 12:00	10:15 to 11:15	1334	336	0.91	56
		12:00 to 14:00	12:00 to 13:00	1279	341	0.94	56
	West (Fri)	15:30 to 18:00	16:00 to 17:00	1266	336	0.94	54

On the basis of the data in Table 22, the summary of the computed minimum, maximum average and standard deviation of the traffic Peak Hour Volume (PHV), the 15-min traffic Peak Volume and the Peak Hour Factor (PHF) results are presented in Table 23. Retail developments showed high PHF values and traffic volumes. The minimum and maximum PHF found were 0.83 and 1.00, respectively which resulted to an average of 0.91. The standard deviation obtained was 0.044 indicating that the PHF values were close to the average PHF value.

Table 23: Summary of Retail Development Results

Variable	Min PHF	Max PHF	Average	Std. Dev.
PHV	624	2385	1392	508
15-Min Vol.	175	676	382	147
PHF	0.83	1.00	0.91	0.044

The computed PHF values in Table 22 show that scattered PHF values were obtained with more values ranging between 0.90 and 1.00 as shown in Figure 47. This therefore shows that a single PHF representing retail developments is required during traffic analysis.

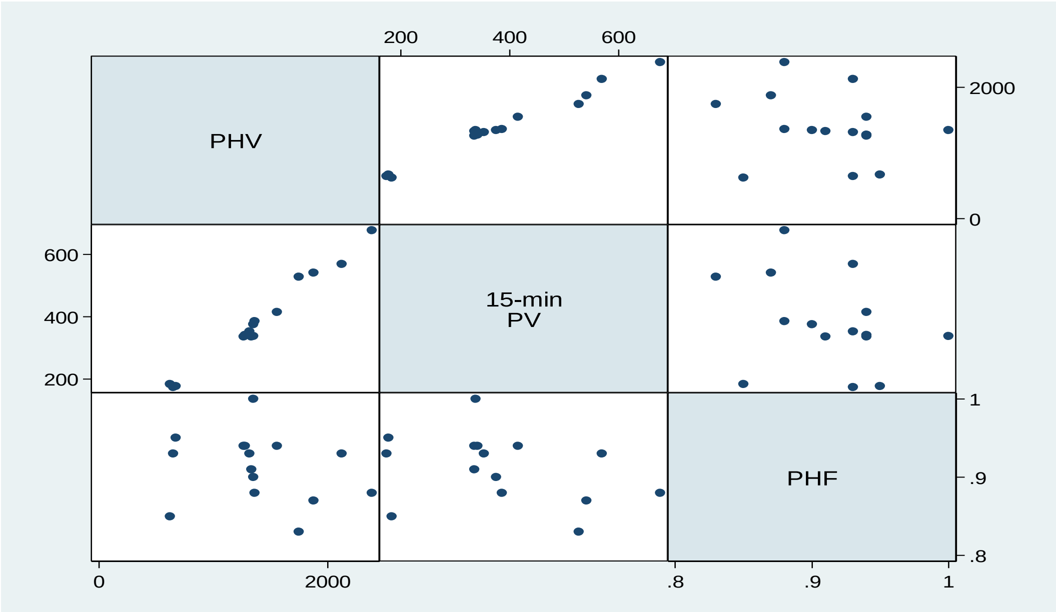


Figure 47: Relationship between PHF, PHV and 15-min Peak Volume at Retail Developments

Figure 48 show the PHF variation at retail developments as computed in Table 22. High PHF values of up to 1 were realised indicating the evenness of traffic flow within a peak hour.

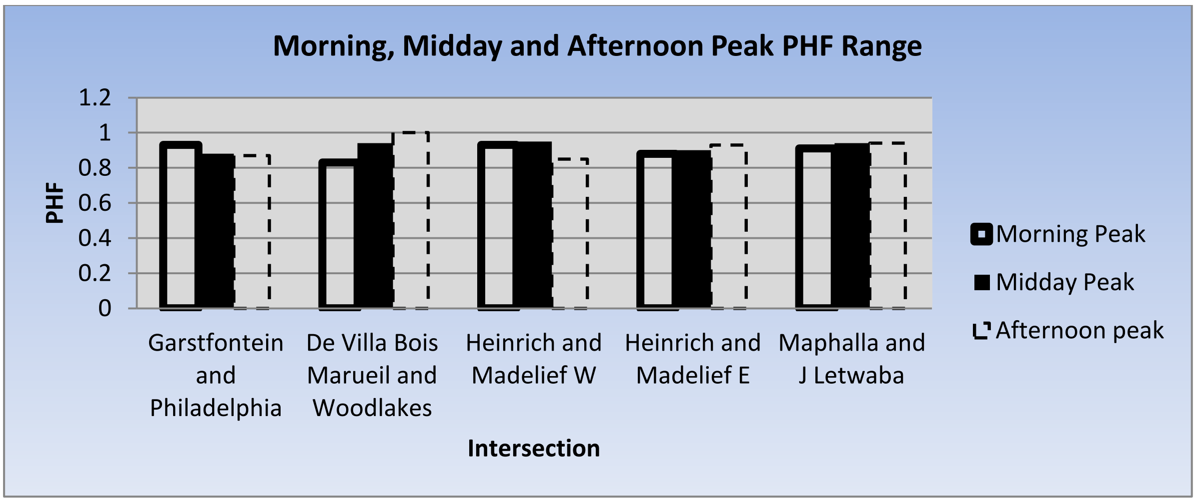


Figure 48: Retail AM and PM peak PHF Range

The computed inbound and outbound traffic flow in Table 22 indicated an equal spread of traffic within a peak hour as shown in Figure 49 during the different peak periods. This can be attributed to different activities associated with retail developments like shopping and entertainment.

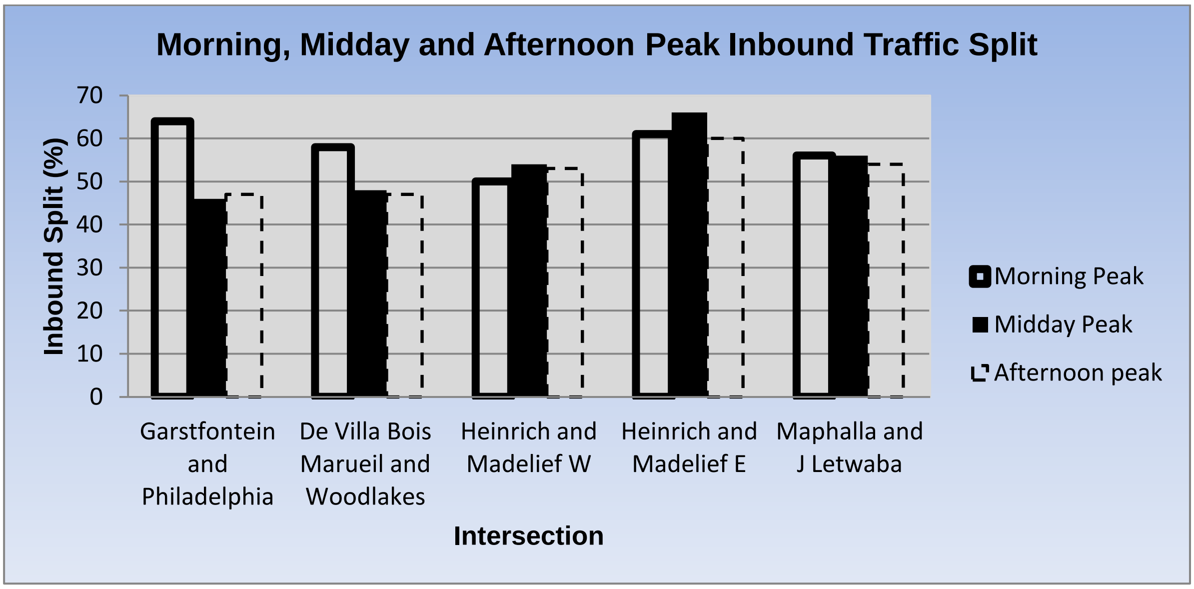


Figure 49: Retail AM and PM peak Traffic Split

Table 24 shows the frequency of the PHF computed in Table 22. The rate of occurrence of the PHF was found to be at 0.93 and 0.94 from the fifteen observations done. This showed that retail developments have a uniform traffic flow distribution during a specific peak hour. In order to select the appropriate value to be used during traffic analysis, Table 25 was used. The most likely peak hour to be associated with retail developments was from 12:00 to 13:00. The PHF of 0.94 also occurred twice within the peak hour mentioned. It is therefore concluded that the PHF of 0.94 and the 12:00 to 13:00 peak hour be used for retail developments during traffic analysis.

Table 24: Overall Retail Development PHF Frequency Results

PHF	Frequency
0.83	1
0.85	1
0.87	1
0.88	2
0.90	1
0.91	1
0.93	3
0.94	3
0.95	1
1.00	1
Total	15

Table 25: Retail Peak Hour Frequency

Peak Hour	Frequency	PHF			Inbound Traffic Split (%)		
09:45 to 10:45	1	0.93					
10:00 to 11:00	1	0.93					
10:15 to 11:15	1	0.91					
10:45 to 12:00	1	0.88					
11:00 to 12:00	1	0.83					
12:00 to 13:00	3	0.90	0.94	0.94	48	56	66
12:30 to 13:30	1	0.95					
13:00 to 14:00	1	0.88					
14:00 to 15:00	1	1.00					
14:15 to 15:15	2	0.85	0.93				
14:30 to 15:30	1	0.87					
16:00 to 17:00	1	0.94					

f. Medical: Hospitals

Table 26 shows the selected intersection and the results to predict the appropriate PHF for medical institutions. Five intersections in the vicinity of hospitals were used for analysis. The AM and PM peak periods were used to predict the possible PHF that could be used during traffic analysis. Medical institutions include private and public hospitals, nursing homes and medical clinics.

Table 26: Selected Intersections Results Representing Medical Institutions

Medical Institutions		Peak Period	Development Inbound and Outbound				
Intersection	Approach		Peak Hour	PHV	15-min PV	PHF	Inbound Split (%)
Church Street and Kalafong Street	South	06:00 to 09:00	06:45 to 07:45	824	212	0.97	38
		15:30 to 18:00	15:45 to 16:45	600	174	0.86	28
Simon Vermooten Drive and Lynnwood Road (1)	South	06:00 to 09:00	07:15 to 08:15	524	150	0.87	70
		15:30 to 18:00	15:45 to 16:45	707	212	0.83	35
Simon Vermooten Drive and Lynnwood Road (2)	South	06:00 to 09:00	06:30 to 07:30	505	151	0.84	69
		15:30 to 18:00	15:30 to 16:30	677	179	0.95	36
Cliffton Avenue and Cantonment Road	North	06:00 to 09:00	06:45 to 07:45	1237	348	0.89	57
		15:30 to 18:00	16:15 to 17:15	1140	321	0.89	54
Voortrekker Road and Malan Street	West	06:00 to 09:00	06:15 to 07:15	807	224	0.90	77
		15:30 to 18:00	15:45 to 16:45	493	136	0.91	24

On the basis of the data in Table 26, the summary of the computed minimum, maximum average and standard deviation of the traffic Peak Hour Volume (PHV), the 15-min traffic Peak Volume and the Peak Hour Factor (PHF) results are presented in Table 27. The PHF values indicate that they are close to the average PHF of 0.89. This was as a result of the low standard deviation of 0.044 obtained. The average PHF of 0.89 also showed that medical institutions have a uniform traffic flow distribution within a peak hour. High traffic volumes at medical institutions could be expected as indicated by the average peak hour traffic volume of 751 Veh/h obtained.

Table 27: Summary of Hospital Results

Variable	Average	Std. Dev.	Minimum PHF	Max PHF
PHV	751	259	493	1237
15-Min Vol.	211	72	135	348
PHF	0.89	0.044	0.83	0.97

The computed PHF in Table 26 showed scattered PHF values for medical institutions are shown on Figure 50. The PHF could vary significantly at this type of land-use. A similar variation is also shown in Figure 51. A single PHF value for medical institutions is therefore required for traffic analysis purposes.

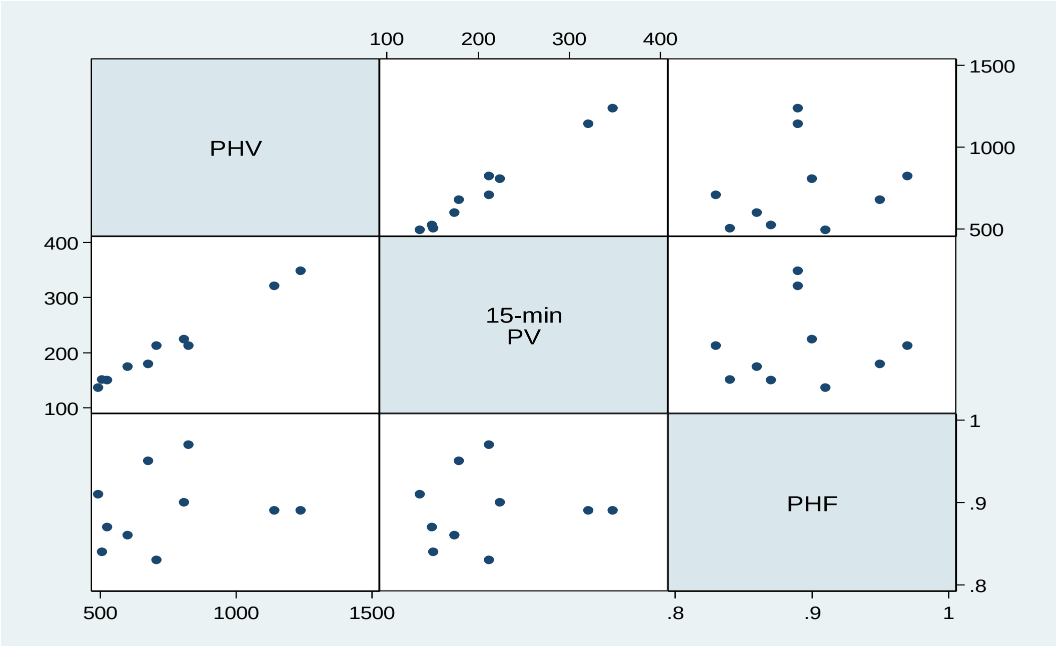


Figure 50: Relationship between PHF, PHV and 15-min Peak Volume at Hospital

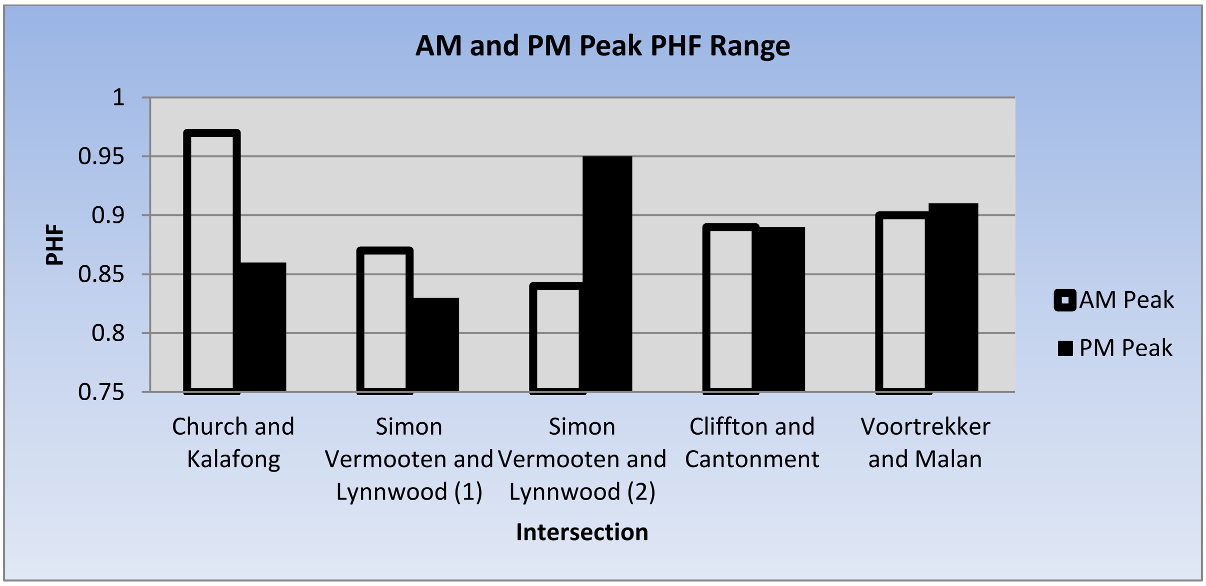


Figure 51: Hospital AM and PM peak PHF Range

The directional traffic split computed in Table 26 at the affected approaches achieved high traffic volumes at the inbound stream during the AM peak periods as shown in Figure 52. High traffic volumes were also realised during the PM peak periods at the outbound stream. It is therefore important to use both the AM and PM peak periods for traffic analysis for this types of land-use.

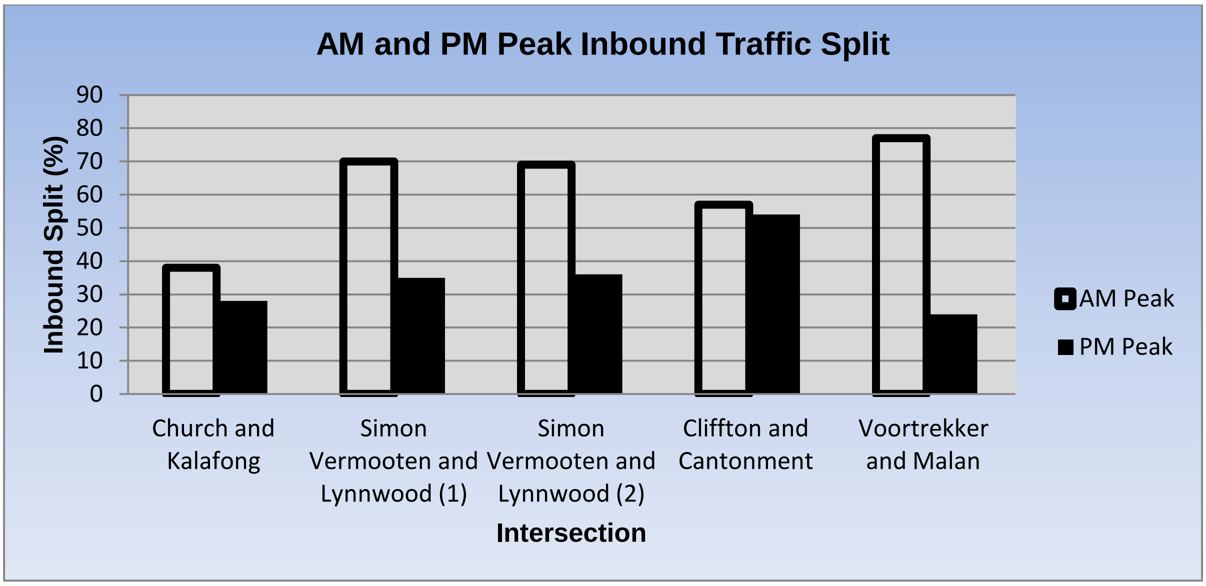


Figure 52: Hospital AM and PM peak Traffic Split

Table 28 shows the PHF frequency for medical institutions as computed in Table 26. The rate of occurrence of the PHF was found to be at 0.89. It should also be noted that the average PHF obtained was equal to 0.89. It is therefore recommended that the PHF of 0.89 be considered for medical institutions during traffic analysis.

Table 28: Overall Medical PHF Frequency Results

PHF	Frequency
0.83	1
0.84	1
0.86	1
0.87	1
0.89	2
0.90	1
0.91	1
0.95	1
0.97	1
Total	10

In support of the recommended PHF of 0.89, Table 29 shows the peak hour that should be considered for traffic analysis. It shows that the 06:45 to 07:45 and the 15:45 to 16:45 could be considered important during medical institutions traffic analysis.

Table 29: Medical Peak Hour Frequency

Peak Hour	Frequency	PHF			Inbound Traffic Split (%)		
06:15 to 07:15	1	0.90					
06:30 to 07:30	1	0.84					
06:45 to 07:45	2	0.89	0.97		38	57	
07:15 to 08:15	1	0.87					
15:30 to 16:30	1	0.95					
15:45 to 16:45	3	0.83	0.86	0.91	24	28	35
16:15 to 17:15	1	0.89					

g. Institutional: Places of public Worship

Table 30 shows the intersection and results obtained from places of public worship. The land-use is mostly characterised by Sunday activities. Traffic counts were conducted on a Sunday. Three intersections in the vicinity of the land-uses were selected and used for analysis. Different peak periods were used for analysis owing to the time associated with each land-use time of worship. There were instances where two or more church services were held at a single place at different times for the day.

Table 30: Selected Intersections Results Representing Places of Public Worship

Places of Public Worship		Peak Period	Development Inbound and Outbound				
Intersection	Approach		Peak Hour	PHV	15-min PV	PHF	Inbound Split (%)
De Villebois Mareuil Drive and Feverwood Street	East	06:00 to 09:00	08:00 to 09:00	1103	383	0.72	98
		09:00 to 12:00	10:00 to 11:00	1139	552	0.52	1
		15:30 to 18:00	16:45 to 17:45	825	255	0.81	96
General Louis Botha Drive and Hatfield Christian Church Access	West	06:00 to 09:00	08:00 to 09:00	102	38	0.67	96
		09:00 to 12:00	11:00 to 12:00	819	359	0.57	12
Nellmapius Drive and Jan Smuts Avenue	South	06:00 to 09:00	07:15 to 08:15	324	91	0.89	84
		09:00 to 12:00	09:00 to 10:00	528	178	0.74	58

On the basis of the data in Table 30, the summary of the computed minimum, maximum average and standard deviation of the traffic Peak Hour Volume (PHV), the 15-min traffic Peak Volume and the Peak Hour Factor (PHF) results are presented in Table 31. The PHF ranged between 0.52 and 0.89 where the average was found to be 0.70. The standard deviation of 0.13 showed that the PHF values obtained were fairly close to the average value. Places of worship carried high traffic volumes as indicated by the average of 691 Veh/h obtained.

Table 31: Summary of Place of Public Worship Results

Variable	Min PHF	Max PHF	Average	Std. Dev.
PHV	102	1139	691	390
15-Min Vol.	38	552	265	180
PHF	0.52	0.89	0.70	0.13

Scattered PHF values were found as shown in Figure 53 from the computed PHF in Table 30. It shows that it is important to produce a single PHF value that could be used for traffic analysis.

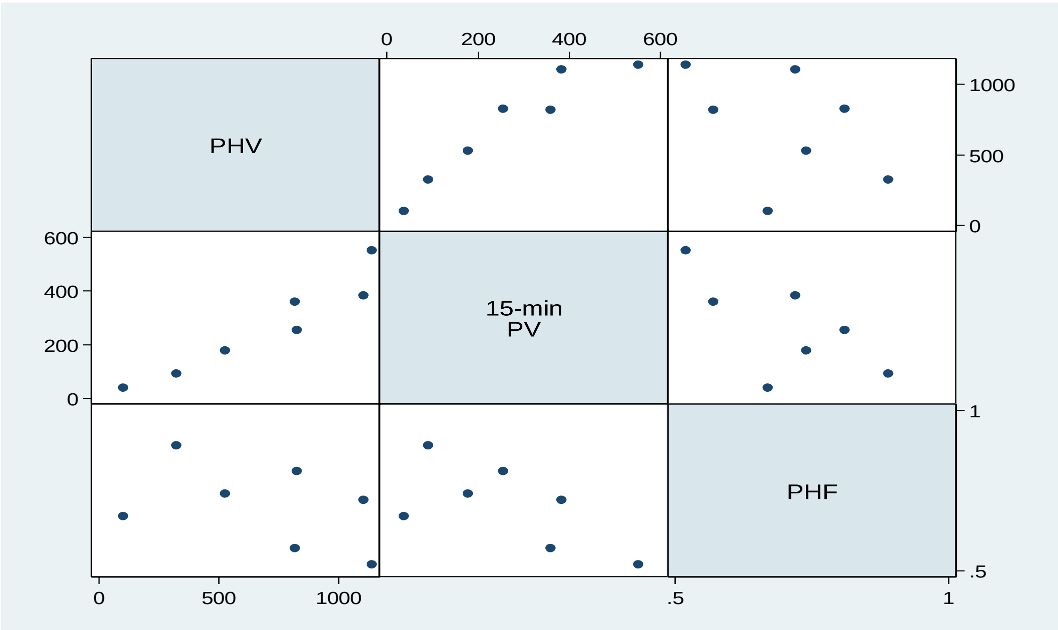


Figure 53: Relationship between PHF, PHV and 15-min Peak Volume at Places of Public Worship

Table 32 shows the frequency of the computed PHF in Table 30. A variety of PHF values were obtained where no value appeared more than once. A PHF to represent the places of worship could not be selected from one of the seven values obtained as it would not be a true representative of this land-use type. Arriving at the appropriate PHF value, the average PHF of 0.70 was selected as it could represent all the seven observations. It was therefore concluded that the PHF of 0.70 be used during traffic analysis for places of worship.

Table 32: Overall Places of Public Worship PHF Frequency Results

PHF	Frequency
0.52	1
0.57	1
0.67	1
0.72	1
0.74	1
0.81	1
0.89	1
Total	7

Table 33 shows the peak hour and the inbound traffic split as computed in Table 30. Since places of worship operate in different peak periods the appropriate peak hour was not determined. It was therefore recommended that the use of the peak hour associated with the time schedule of each place of public worship should be considered during traffic analysis. The directional traffic split also shows that before services, more traffic volumes were experienced at the inbound stream and more traffic at the outbound stream after church services.

Table 33: Places of Public Worship Peak Hour Frequency

Peak Hour	Frequency	PHF		Inbound Traffic Split (%)	
07:15 to 08:15	1	0.89		84	
08:00 to 09:00	2	0.67	0.72	96	98
09:00 to 10:00	1	0.74		58	
10:00 to 11:00	1	0.52		1	
11:00 to 12:00	1	0.57		12	
16:45 to 17:45	1	0.81		96	

5.2 Development of PHF design chart

The analysis and recommendations done in sub-section 5.1, assisted in determining the PHF per land-use type as shown in Table 34. The table was developed as a design chart showing the recommended PHF values associated with each land-use type as well as the peak hours to be considered during traffic analysis. The peak hours shown should be used as a guide for the appropriate peak period to conduct traffic counts for traffic analysis purposes. The possible directional splits at each land-use were indicated.

Table 34: Peak Hour Factor per Land-use type

Land-Use Type	Peak Hour Factor	Peak Periods to Consider During Analysis			Directional Split
		Week days		Weekend	
		AM Peak Hour	PM Peak Hour		
Residential	0.86	07:00 to 08:00	16:45 to 17:45		70/30
Office	0.89	07:30 to 08:30	16:00 to 17:00		70/30
Industrial	0.89	06:30 to 07:30	16:00 to 17:00		80/20
Retail	0.94		Friday PM peak	12:00 to 13:00	60/40; 50/50
Medical	0.89	06:45 to 07:45	15:45 to 16:45		70/30; 60/40
School	0.84	06:45 to 07:45	Midday and Afternoon Peak		50/50
Church	0.70	The use of appropriate peak hour relating to the analysed Church to be considered			95/05

5.3 PHF comparison in traffic analysis

Intersection capacity analysis was conducted to compare the HCM PHF default value and the computed PHF for each land-use type. The purpose was to indicate the impact a PHF could have on the final design results. SIDRA intersection software was used to analyse the intersections. One intersection for each land-use was used to indicate the possible changes in intersection capacity analysis using a different PHF.

The saturation flow rate of 2050 Veh/h was used in the capacity analysis. Saturation flow rate is the equivalent hourly rate at which previously queued vehicles can traverse an intersection approach under prevailing conditions, assuming that the green signal is available at all times and no lost times are experienced (Highway Capacity Manual, 2000).

Table 35 shows the results obtained using the same input parameters with different PHF values. The PHF of 0.95 recommended for highly congested traffic conditions was also used. The differences in traffic flow rate, the degree of saturation also known as the volume to capacity ratio (c/v), average delay in second and the Level of Service (LOS) are shown. An example of the results produced by the SIDRA Solution Software is shown in Appendix D.

Table 35: Traffic capacity analysis results

Land-use	Produced PHF for each land-use						HCM default value, 0.92				Congested conditions PHF, 0.95			
	Peak period	PHF	Demand Flow (Veh/h)	V/C	Ave. delay (Sec)	LOS	Demand Flow (Veh/h)	V/C	Ave. Delay (Sec)	LOS	Demand Flow (Veh/h)	V/C	Ave. Delay (Sec)	LOS
Residential	AM	0.86	1950	0.74	22.6	C	1823	0.66	21.3	C	1765	0.63	21.3	C
	PM		2442	1.00	19.3	B	2283	0.96	18.3	B	2211	0.96	18.1	B
Office	AM	0.89	4253	1.10	23.6	C	4114	1.09	21.5	C	3984	1.09	20.6	C
	PM		4322	0.94	28.6	C	4182	0.91	23.7	C	4049	0.88	20.6	C
Industrial	AM	0.89	3892	1.00	25.2	C	3765	1.00	25.1	C	3646	1.00	24.4	C
	PM		2998	0.78	22.3	C	2900	0.75	21.4	C	2808	0.74	20.8	C
School	AM	0.84	4211	1.00	24.0	C	3845	1.00	23.2	C	3723	1.00	16.9	C
Retail	Midday	0.94	3874	1.35	118.4	F	3959	1.35	129.5	F	3834	1.45	113.3	F
Medical	AM	0.89	4310	1.38	214.1	F	4170	1.34	195.4	F	4038	1.34	178.2	F
	PM		4449	1.34	121.8	F	4304	1.34	110.8	F	4168	1.34	101.3	F
Church	AM	0.70	2477	0.77	9.8	A	1885	0.69	9.9	A	1825	0.67	9.7	A
	Morning		3976	0.86	20.8	C	3025	0.79	13.9	B	2929	0.76	13.6	B

Table 36 shows the effect of using inappropriate PHF values on the final design results. It shows the extent at which the final results could be underestimated (-ve) or overestimated (+ve). The LOS at the intersection did not indicate any changes for the overall intersection results. However, other intersection performance measures were affected by using different PHF values, 0.92 and 0.95. The default values adjusted the demand flow rate by up to 26%. The volume to capacity ratio and the delay were overestimated by up to 11 to 15% and 33 to 35%, respectively.

Table 36: Effect of varying PHF during traffic analysis

Land-use	Peak period	(%) Difference to 0.92			(%) Difference to 0.95		
		Demand Flow	V/C	Average delay	Demand Flow	V/C	Average delay
Residential	AM	7	11	6	9	15	6
	PM	7	4	5	9	4	6
Office	AM	3	1	9	6	1	13
	PM	3	3	17	6	6	28
Industrial	AM	3	0	0	6	0	3
	PM	3	4	4	6	5	7
School	AM	9	0	3	12	0	30
Retail	Midday	-2	0	-9	1	-7	4
Medical	AM	3	3	9	6	3	17
	PM	3	0	9	6	0	17
Church	AM	24	10	-1	26	13	1
	Morning	24	8	33	26	12	35

The use of higher PHF on all the land-uses excluding the retail developments will overestimate the intersection measure of effectiveness. Retail developments carries high traffic volumes, hence it is recommended that a PHF of 0.94 be used rather than the default value of 0.92. PHF should not be adjusted to obtain the required measures of effectiveness at analysed intersection. Adjusting the PHF could affect the obligation of the developer and/or the relevant authority to undertake mitigating measures on the road network proposed in the TIA recommendations. Changes in land-use could affect the existing PHF at nearby intersection thus affecting the performance measure. Improvements on the intersection configuration by introducing additional through and turning movements, where appropriate, should be considered. Other processes like provision of efficient public transport system and Non-Motorised Transport (NMT) could be employed to obtain the required measures of effectiveness. It is therefore recommended that the computed PHF for each land-use be used during traffic analysis.

CHAPTER 6 - CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The main aim of the study was to investigate the effect land-use change could have on the traffic peak hour factor. The specific objectives were to determine the peak hour factor for different land-use types, develop a design chart which might be considered for inclusion in the National Traffic Data Manual and to compare the designs using the existing PHF and the proposed PHF values. The produced results will thus enhance the use of the local default values of the PHF per land-use type and to ensure consistency on the final roadway design results during traffic analysis.

a) Land-use change influences the traffic distribution on the road network in the surrounding area where choice of accessibility to a development is immensely available. Due to the change, the peak hours during different peak periods change as well as the peak traffic volumes.
b) Due to the day-to-day variability of the peak hour traffic volumes, a variety of values were obtained. These values can be used to compute input parameters thus producing results that could underestimate or overestimate the intersection performance measures during traffic analysis.
c) Land-uses that could be characterised under employment sector obtained a similar PHF of 0.89. The land-uses were offices, industrial and medical: hospital. Residential and institutional: schools obtained a PHF 0.86 and 0.84, respectively. Retail developments which carry high traffic volumes during the weekends indicated a PHF of 0.94. While places of worship with the traffic flow focused at the last 15-min peak before services obtained a PHF of 0.70.
d) A design chart in the form of a table was developed to indicate the predicted PHF per land-use type selected and traffic parameters that should be considered during traffic analysis, the traffic peak hour and directional split.
e) The PHF differ from land-use to land-use and the appropriate value must be used during traffic analysis. The default values overestimated the degree of saturation and the average traffic delay of an intersection by up to 15% and 35%, respectively as well as the traffic flow rate by up to 26%.

From the results presented, it is evident that adjusting the PHF will have an effect on the final intersection design results.

6.2 Recommendations

a) The computed PHF values for each land-use type should be used during traffic analysis for fair and consistent design results to be obtained.

b) Suitable peak periods and days for the week for each land-use type should be applied during data collection for traffic analysis purposes.

c) Further traffic counts should be obtained from another region within the country to confirm the findings of this study.

d) Surveys and analysis for other land-uses that were not analysed should be conducted.

e) The relationship and the effect of previously queued vehicles on the PHF due to long queues and delays should be investigated. This can be achieved at intersection with a PHF between 0.95 and 1.00.

f) The directional split percentage at an intersection approach for each land-use were not extensively covered in this research, therefore further investigation will be required.

g) The amount of internal trips absorbed in a mix land-use development must be investigated for the purposes of traffic analysis. The PHF for such land-uses should also be determined.

h) Heavy vehicle adjustment factor for industrial and retail developments should be investigated for traffic analysis purposes.

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APPENDICES

APPENDIX A

Table A1: Intersection Traffic Counts

Enter Date	HEBRON ROAD AND UMPHAFA STREET INTERSECTION												Compare
of Count	Enter Land Use Codes for land-use served by the road. Enter "Code" if not serving a land-use												Totals
25	Southern Approach			Western Approach			Northern Approach			Eastern Approach			with
August	210	Single Dwelling Units		Code	Land Use		210	Single Dwelling Units		Code	Land Use		Count
2010	UMPHAFA STREET			HEBRON			UMPHAFA STREET			HEBRON			Sheet
Time	1 LT	2 ST	3 RT	4 LT	5 ST	6 RT	7 LT	8 ST	9 RT	10 LT	11 ST	12 RT	Total
06:00 to 06:15	36	15	52	11	182	40	50	16	1	30	78	15	526
06:15 to 06:30	35	8	43	5	162	33	43	12	2	20	59	7	429
06:30 to 06:45	32	8	85	11	143	20	28	5	2	19	111	3	467
06:45 to 07:00	34	4	105	7	128	36	20	2	3	29	89	5	462
07:00 to 07:15	27	4	84	2	100	27	21	2	3	9	88	4	371
07:15 to 07:30	38	8	88	2	52	14	12	4	6	17	65	31	337
07:30 to 07:45	41	4	84	3	62	11	14	4	4	10	37	4	278
07:45 to 08:00	23	0	47	7	47	32	5	8	1	9	29	3	211
08:00 to 08:15	27	5	40	3	51	8	7	3	2	10	30	1	187
08:15 to 08:30	23	5	41	1	45	22	7	5	1	17	32	2	201
08:30 to 08:45	27	6	33	4	37	29	5	4	1	14	65	2	227
08:45 to 09:00	20	3	35	1	23	17	3	1	2	11	41	4	161
09:00 to 09:15	35	5	40	3	38	12	6	7	5	17	59	2	229
09:15 to 09:30	33	9	27	6	45	21	3	4	2	10	43	4	207
09:30 to 09:45	28	6	30	5	43	31	0	4	1	16	41	4	209
09:45 to 10:00	21	4	23	4	42	12	2	1	2	14	40	1	166
10:00 to 10:15	34	4	42	5	50	22	4	2	4	13	43	3	226
10:15 to 10:30	31	2	30	8	48	21	2	4	9	12	58	9	234
10:30 to 10:45	28	3	34	6	47	24	5	4	2	10	42	1	206
10:45 to 11:00	27	8	35	7	55	28	1	6	2	15	44	3	231
11:00 to 11:15	38	9	41	5	50	22	0	0	3	22	46	4	240
11:15 to 11:30	29	4	25	5	48	28	2	5	3	15	36	3	203
11:30 to 11:45	18	2	25	5	28	28	4	3	1	14	56	1	185
11:45 to 12:00	15	6	32	6	38	27	3	8	3	15	48	6	207
12:00 to 12:15	22	6	28	3	47	33	4	6	1	8	51	1	210
12:15 to 12:30	25	1	22	2	40	16	2	7	1	16	48	2	182
12:30 to 12:45	15	7	28	1	27	28	1	11	1	18	27	3	167
12:45 to 13:00	14	3	4	2	55	21	1	5	2	10	35	1	153
13:00 to 13:15	29	4	27	4	47	27	3	6	0	10	50	6	213
13:15 to 13:30	27	8	22	3	37	26	0	6	1	16	60	4	210
13:30 to 13:45	19	5	55	0	46	33	3	0	1	14	28	7	211
13:45 to 14:00	24	6	23	2	43	24	1	1	0	15	55	0	194
14:00 to 14:15	24	2	52	3	39	34	3	3	1	13	37	5	216
14:15 to 14:30	19	8	33	1	30	19	2	5	0	26	49	9	201
14:30 to 14:45	27	9	26	4	38	26	2	2	0	26	58	11	229
14:45 to 15:00	26	5	35	2	31	42	10	3	1	31	52	10	248
15:00 to 15:15	33	4	22	1	25	10	0	0	1	19	39	7	161
15:15 to 15:30	24	6	29	2	18	22	4	1	1	23	45	6	181
15:30 to 15:45	29	8	41	0	27	41	2	0	0	31	61	7	247
15:45 to 16:00	32	3	37	3	35	35	3	1	0	24	57	4	234
16:00 to 16:15	37	9	27	5	35	42	4	3	1	53	85	14	315
16:15 to 16:30	36	4	36	4	45	56	4	6	1	61	120	7	380
16:30 to 16:45	40	3	35	2	52	42	1	9	2	73	138	17	414
16:45 to 17:00	19	5	23	3	33	39	4	6	0	62	115	12	321
17:00 to 17:15	36	9	35	7	51	40	9	9	6	81	119	15	417
17:15 to 17:30	32	2	35	4	48	28	3	8	2	70	181	25	438
17:30 to 17:45	28	5	30	3	40	22	2	6	1	81	203	30	451
17:45 to 18:00	15	2	20	1	38	16	1	4	2	90	197	19	405
Total	1332	256	1846	184	2491	1287	316	222	91	1239	3190	344	12798

Approach and Turning Directions

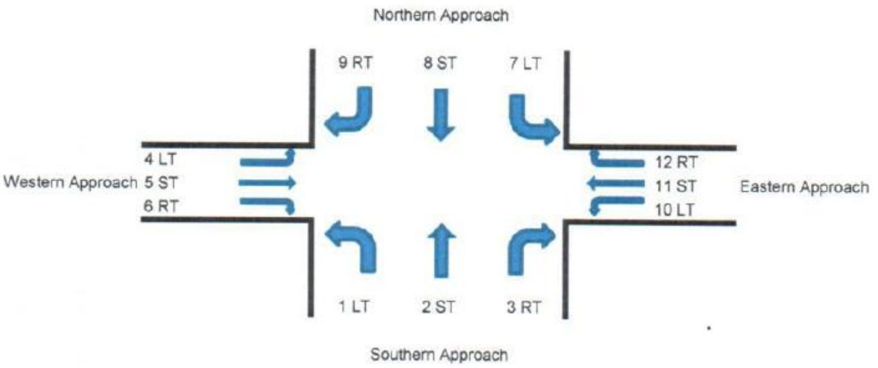


Table A2: Traffic Counts Results

Street system					
Peak Period		Peak Hour	Development In + Outbound		
Peak Hour	Period	(One Hour)	Hour Vol	15-Min Vol	PHF
AM Peak	06:00 to 09:00	6:00 to 7:00	952	260	0.915
Morning	09:00 to 12:00	10:15 to 11:15	390	106	0.920
Midday	12:00 to 14:00	13:00 to 14:00	366	98	0.934
Afternoon	14:00 to 15:30	14:00 to 15:00	334	96	0.870
PM Peak	15:30 to 18:00	17:00 to 18:00	877	243	0.902

210 Single Dwelling Units			Peak hour of the street system									South
Peak Period		Peak Hour	Development In + Outbound			Development Inbound			Development Outbound			Inbound
Peak Hour	Period	(One Hour)	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Split
AM Peak	06:00 to 09:00	6:00 to 7:00	719	210	0.856	262	86	0.762	457	143	0.799	36%
Morning	09:00 to 12:00	10:15 to 11:15	454	132	0.860	168	49	0.857	286	88	0.813	37%
Midday	12:00 to 14:00	13:00 to 14:00	427	126	0.847	178	48	0.927	249	79	0.788	42%
Afternoon	14:00 to 15:30	14:00 to 15:00	496	142	0.873	230	76	0.757	266	78	0.853	46%
PM Peak	15:30 to 18:00	17:00 to 18:00	704	210	0.838	455	130	0.875	249	80	0.778	65%

210 Single Dwelling Units			Peak hour of the development									South
Peak Period		Peak Hour	Development In + Outbound			Development Inbound			Development Outbound			Inbound
Peak Hour	Period	(One Hour)	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Split
AM Peak	06:00 to 09:00	6:00 to 7:00	719	210	0.856	262	86	0.762	457	143	0.799	36%
Morning	09:00 to 12:00	10:30 to 11:30	460	132	0.871	179	49	0.913	281	88	0.798	39%
Midday	12:00 to 14:00	13:00 to 14:00	427	126	0.847	178	48	0.927	249	79	0.788	42%
Afternoon	14:00 to 15:30	14:00 to 15:00	496	142	0.873	230	76	0.757	266	78	0.853	46%
PM Peak	15:30 to 18:00	16:15 to 17:15	765	210	0.911	484	130	0.931	281	80	0.878	63%

Code Land Use			Peak hour of the street system									West
Peak Period		Peak Hour	Development In + Outbound			Development Inbound			Development Outbound			Inbound
Peak Hour	Period	(One Hour)	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Split
AM Peak	06:00 to 09:00											
Morning	09:00 to 12:00											
Midday	12:00 to 14:00											
Afternoon	14:00 to 15:30											
PM Peak	15:30 to 18:00											

Code Land Use			Peak hour of the development									West
Peak Period		Peak Hour	Development In + Outbound			Development Inbound			Development Outbound			Inbound
Peak Hour	Period	(One Hour)	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Split
AM Peak	06:00 to 09:00											
Morning	09:00 to 12:00											
Midday	12:00 to 14:00											
Afternoon	14:00 to 15:30											
PM Peak	15:30 to 18:00											

210 Single Dwelling Units			Peak hour of the street system									North
Peak Period		Peak Hour	Development In + Outbound			Development Inbound			Development Outbound			Inbound
Peak Hour	Period	(One Hour)	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Split
AM Peak	06:00 to 09:00	6:00 to 7:00	283	108	0.655	99	41	0.604	184	67	0.687	35%
Morning	09:00 to 12:00	10:15 to 11:15	103	34	0.757	65	19	0.855	38	15	0.633	63%
Midday	12:00 to 14:00	13:00 to 14:00	71	23	0.772	49	15	0.817	22	9	0.611	69%
Afternoon	14:00 to 15:30	14:00 to 15:00	101	31	0.815	69	24	0.719	32	14	0.571	68%
PM Peak	15:30 to 18:00	17:00 to 18:00	175	55	0.795	122	38	0.803	53	24	0.552	70%

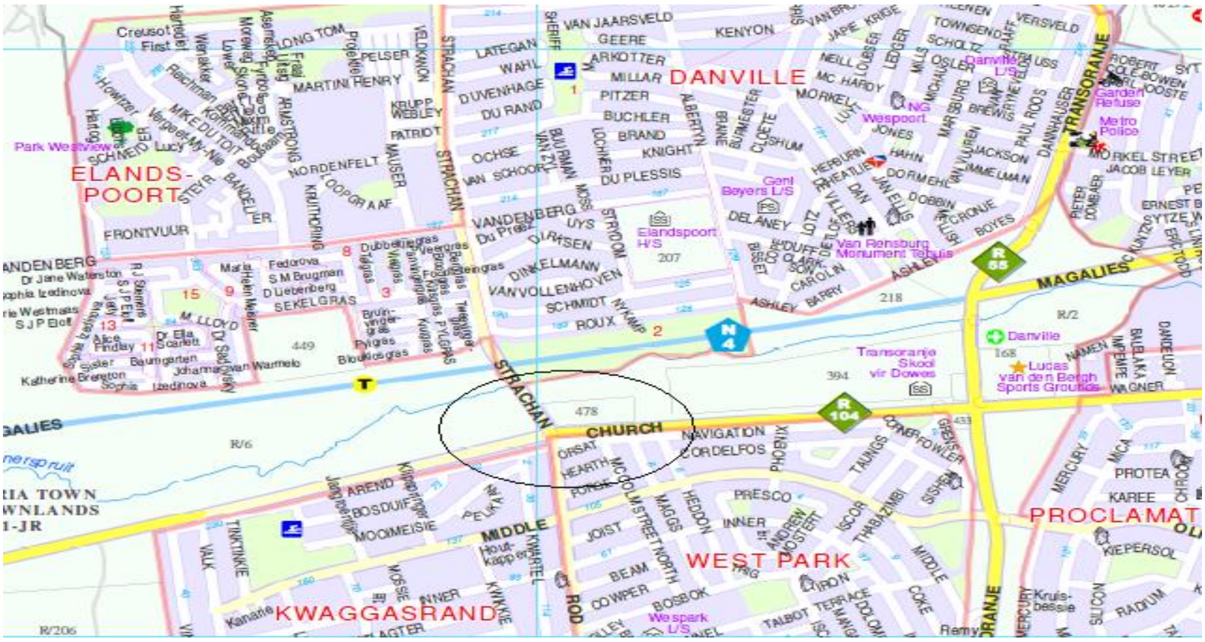
210 Single Dwelling Units			Peak hour of the development									North
Peak Period		Peak Hour	Development In + Outbound			Development Inbound			Development Outbound			Inbound
Peak Hour	Period	(One Hour)	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Split
AM Peak	06:00 to 09:00	6:00 to 7:00	283	108	0.655	99	41	0.604	184	67	0.687	35%
Morning	09:00 to 12:00	10:00 to 11:00	104	34	0.765	59	19	0.776	45	15	0.750	57%
Midday	12:00 to 14:00	12:30 to 13:30	83	24	0.865	46	15	0.767	37	13	0.712	55%
Afternoon	14:00 to 15:30	14:00 to 15:00	101	31	0.815	69	24	0.719	32	14	0.571	68%
PM Peak	15:30 to 18:00	16:45 to 17:45	176	55	0.800	120	38	0.789	56	24	0.583	68%

Code Land Use			Peak hour of the street system									East
Peak Period		Peak Hour	Development In + Outbound			Development Inbound			Development Outbound			Inbound
Peak Hour	Period	(One Hour)	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Split
AM Peak	06:00 to 09:00											
Morning	09:00 to 12:00											
Midday	12:00 to 14:00											
Afternoon	14:00 to 15:30											
PM Peak	15:30 to 18:00											

Code Land Use			Peak hour of the development									East
Peak Period		Peak Hour	Development In + Outbound			Development Inbound			Development Outbound			Inbound
Peak Hour	Period	(One Hour)	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Hour Vol	15-Min Vol	PHF	Split
AM Peak	06:00 to 09:00											
Morning	09:00 to 12:00											
Midday	12:00 to 14:00											
Afternoon	14:00 to 15:30											
PM Peak	15:30 to 18:00											

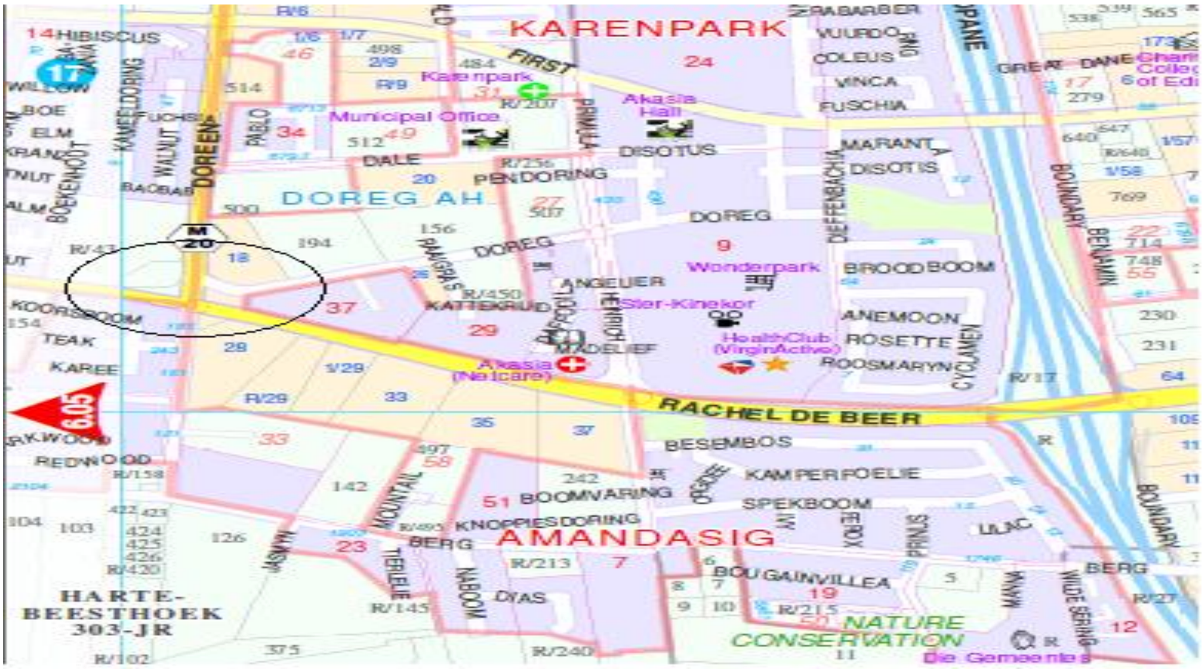
APPENDIX B

Residential Development Intersections



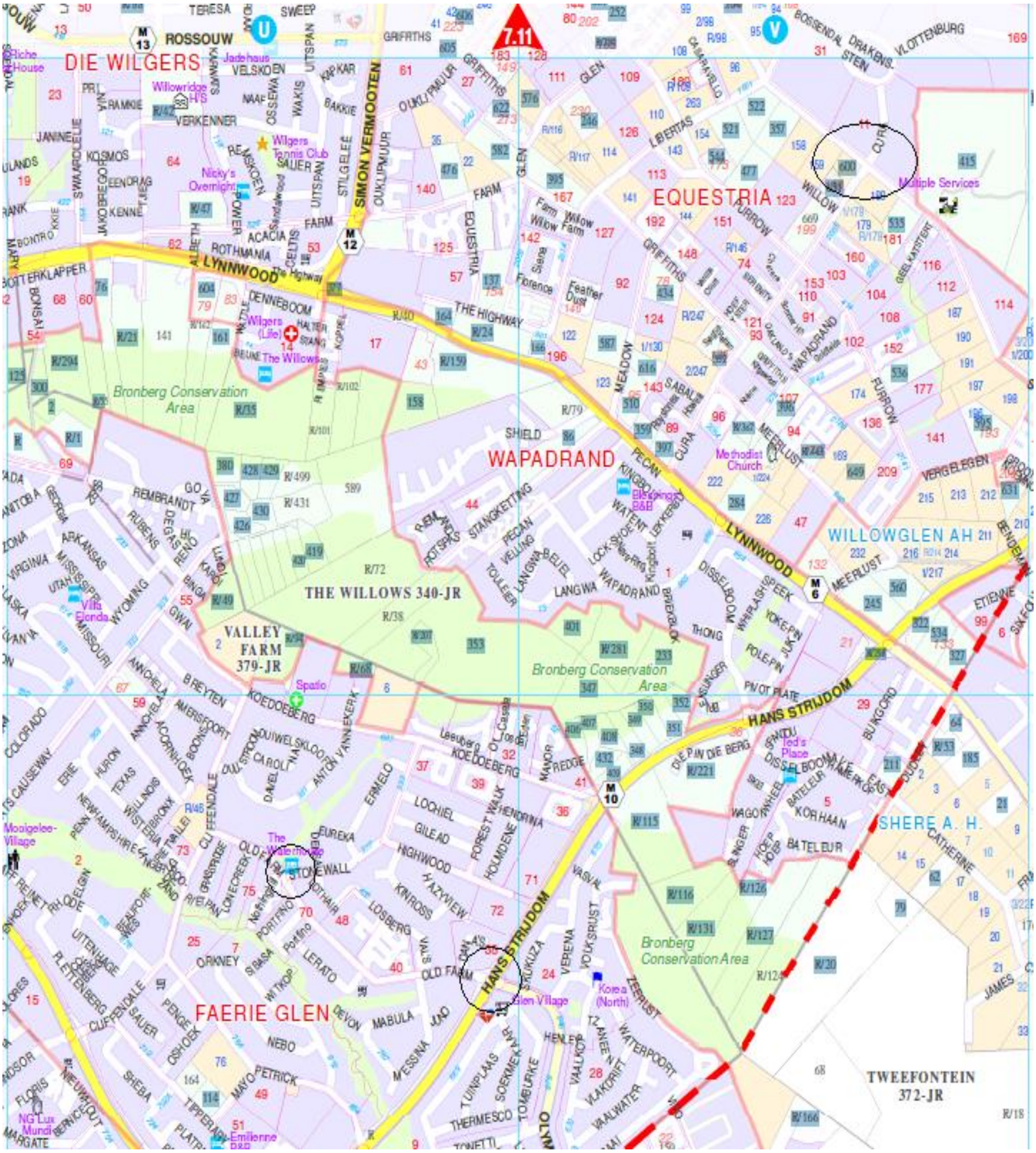
Map B1: Church Street and Strachan-Rod Street Intersection

Map B2: Zambesi Drive and Zambezi Estate Avenue (Avocet) Intersection

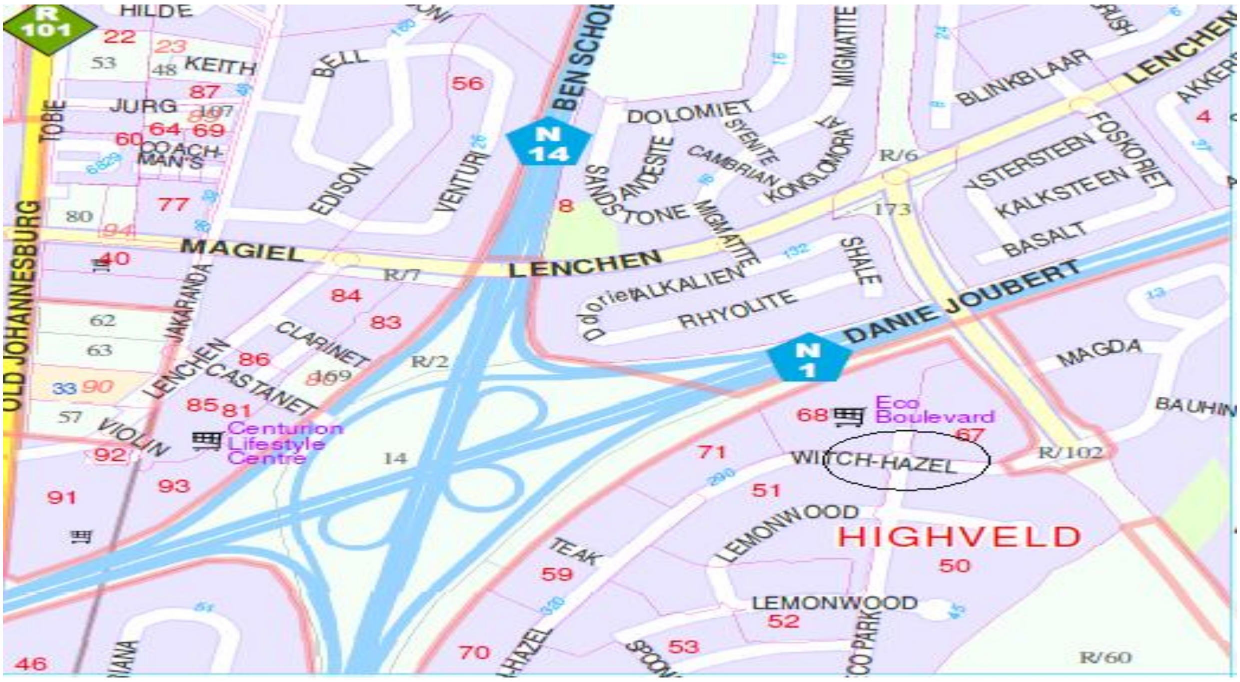


Map B3: Brits Road (Rachel De Beer) and Doreen Road Intersection

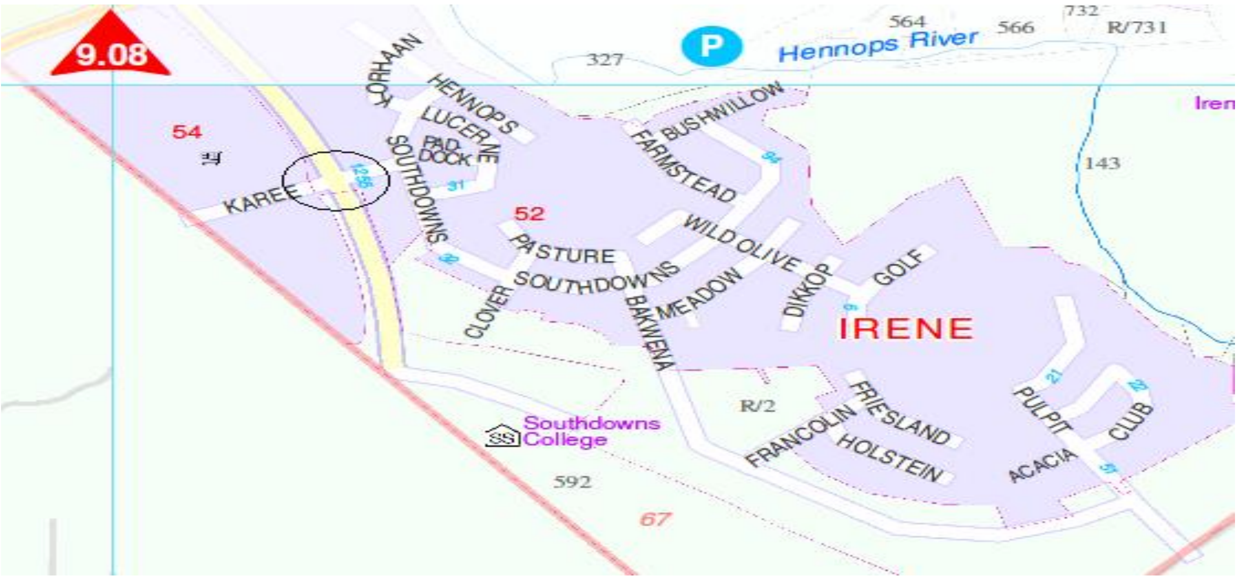
Map B4: Hebron Road and Umphafa Street Intersection



Map B5: Old Farm Road and Stonewall Boulevard Intersection (1)
Hans Strijdom Drive and Old Farm Intersection (2)
Cura Avenue and Stellenberg Road (3)



Map B6: Witch Hazel Avenue and Eco Park Boulevard Intersection



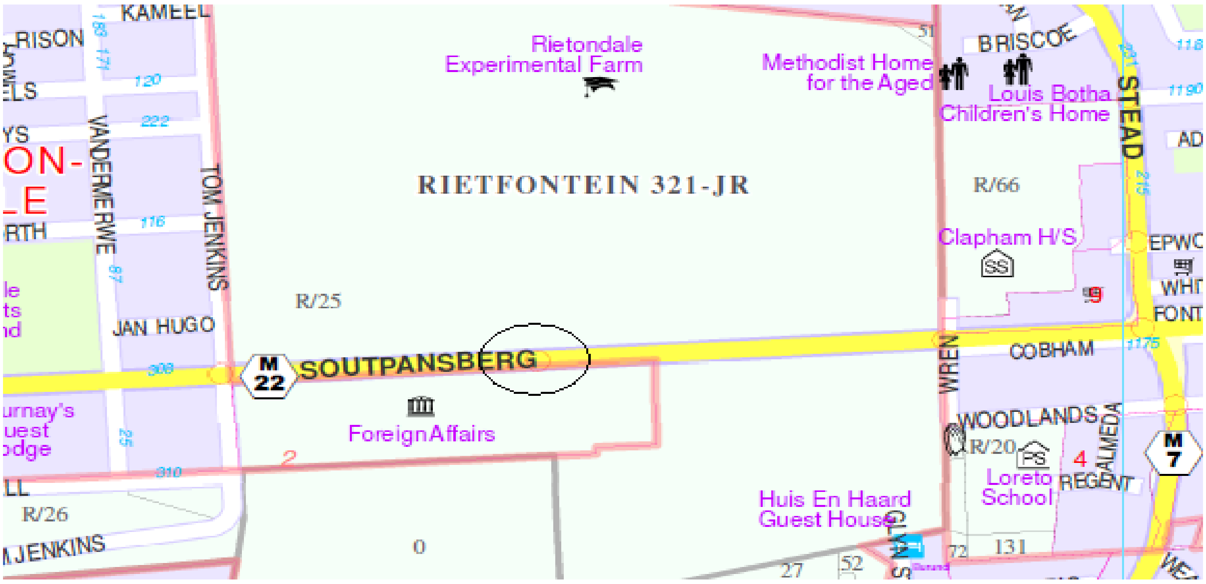
Map B7: John Vorster Drive and Karee Street Intersection

Office Developments Intersections

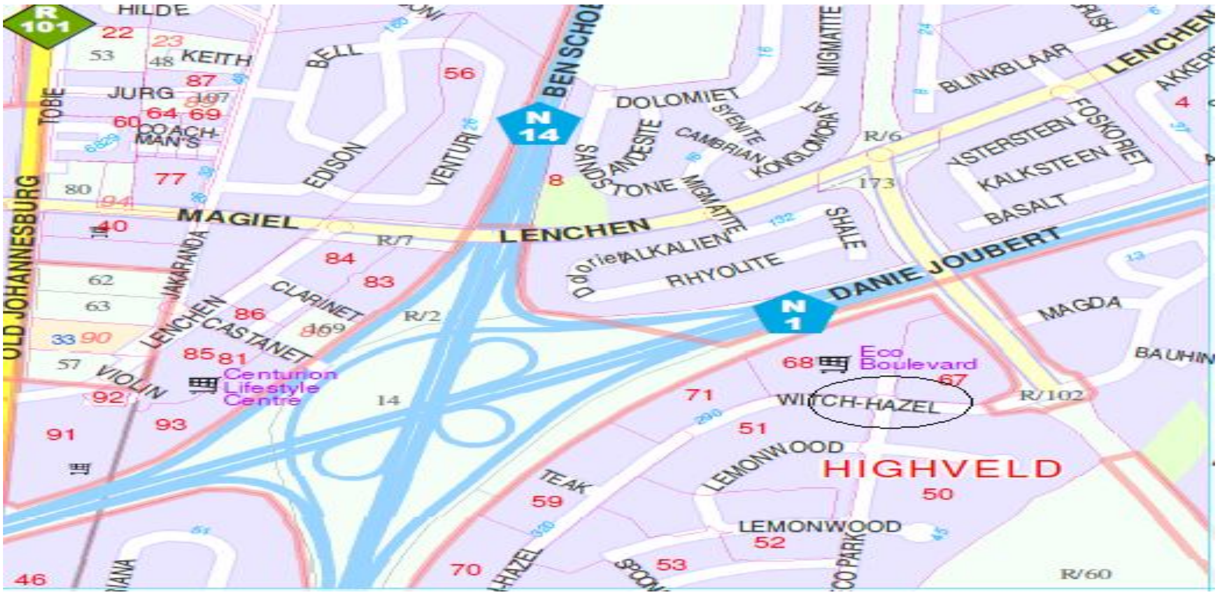
Map B8: Meiring Naude and Quitin Brand Street Intersection (1)

Meiring Naude and Hotel Street Intersection (2)

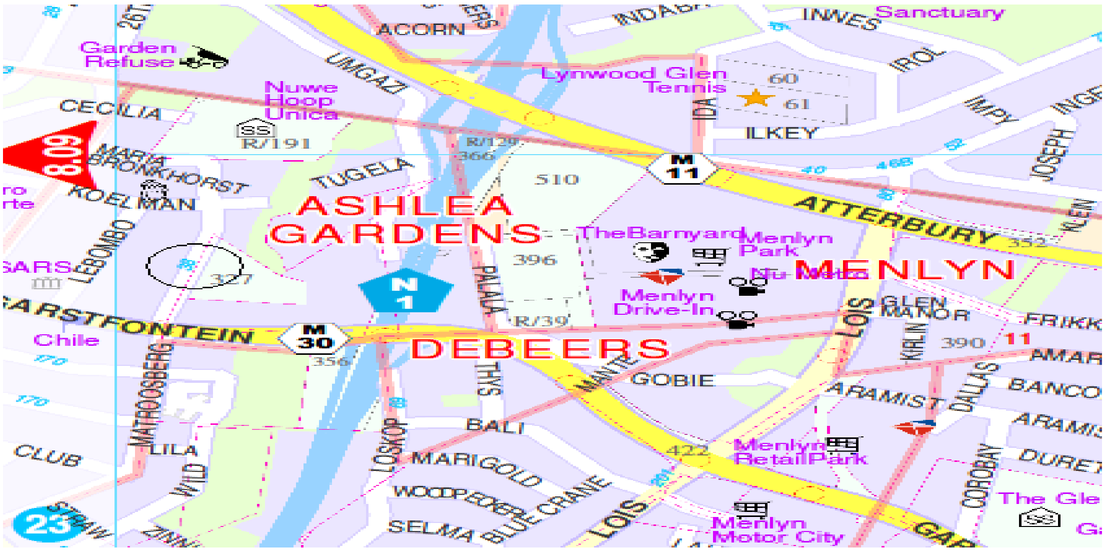
Meiring Naude and CSIR Entrance Intersection (3)



Map B9: Soutpansberg Road and Foreign Affairs Intersection

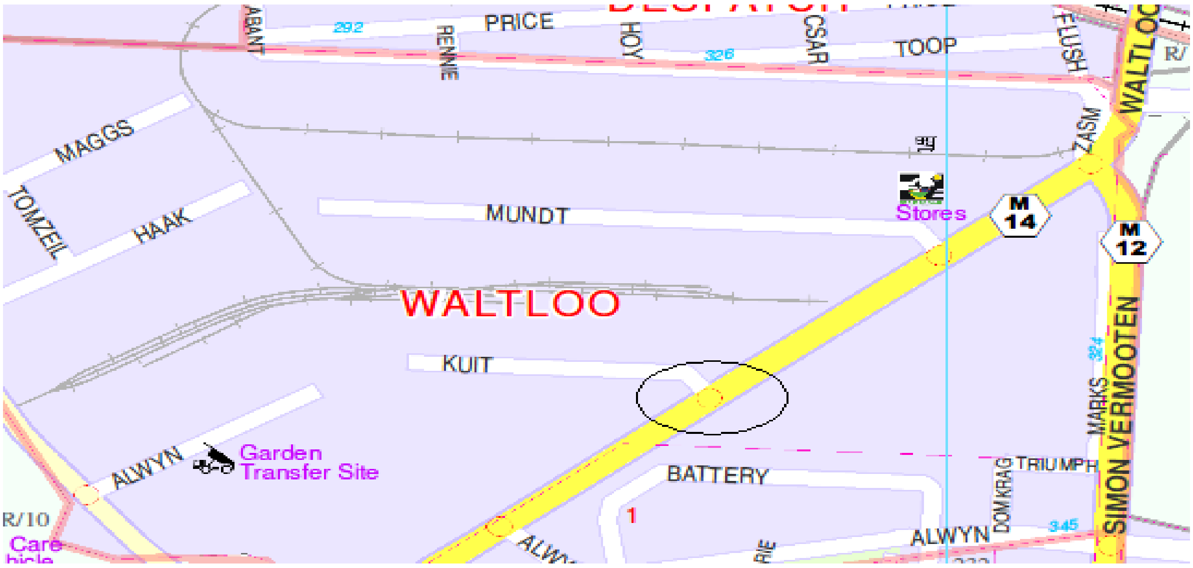


Map B10: Witch Hazel Avenue and Ecopark Boulevard Intersection



Map B11: Matroosberg Street and River Walk Park Entrance Intersection

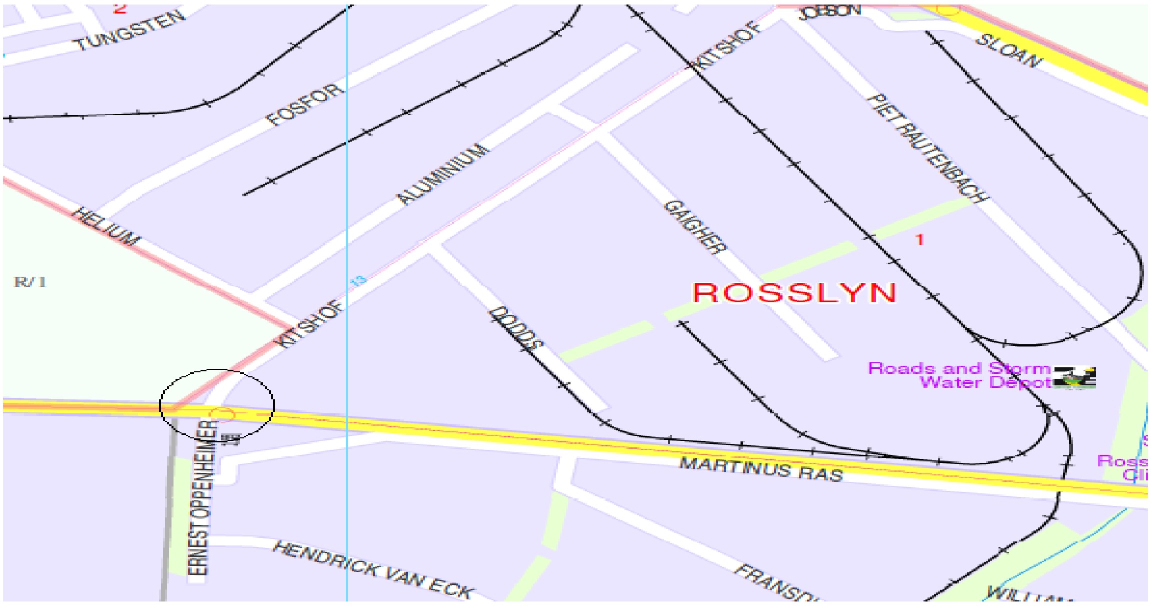
Industrial Development Intersections



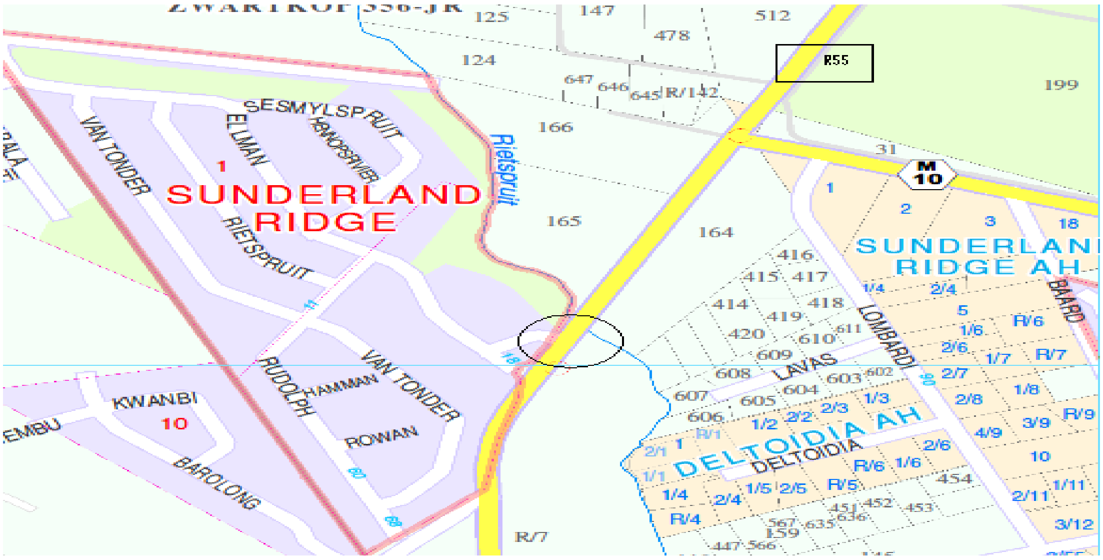
Map B12: Waltloo Road and Kuit Street Intersection

Map B13: Pretoria Road and Fakkel Street Intersection (1)

Dykor Road and Moreleta Street Intersection (2)

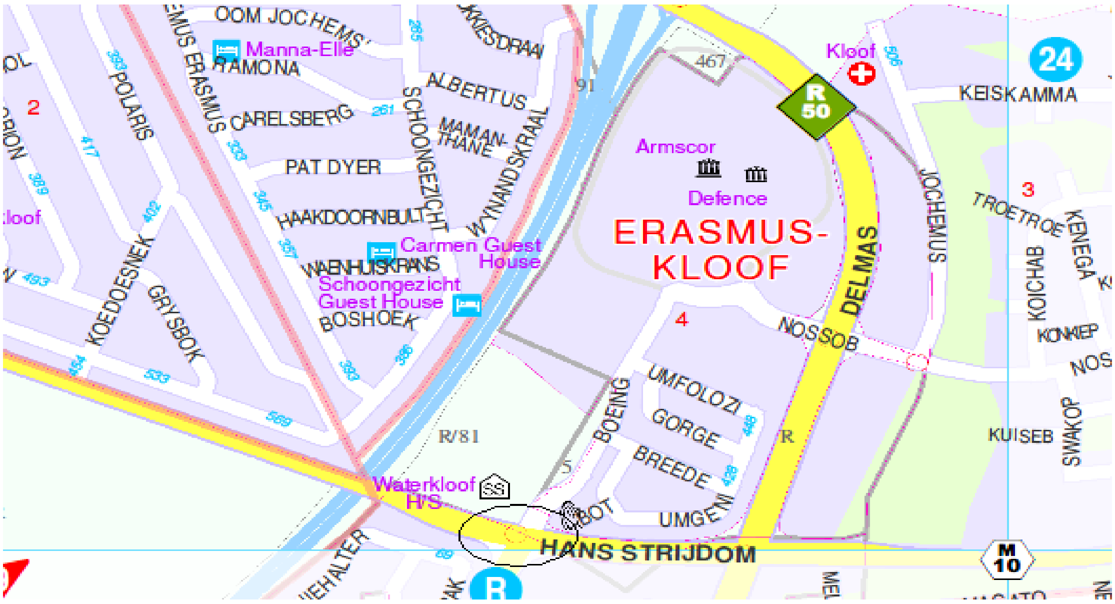


Map B14: R566 and Ernest Opperheimer Street Intersection

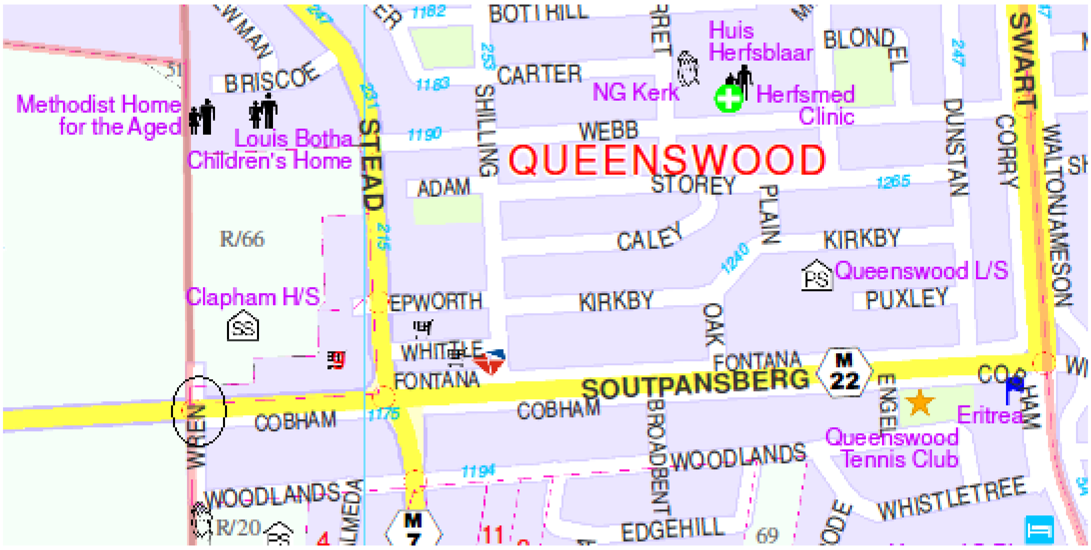


Map B15: R55 and Ellman Street Intersection

Institutional: Schools Intersections

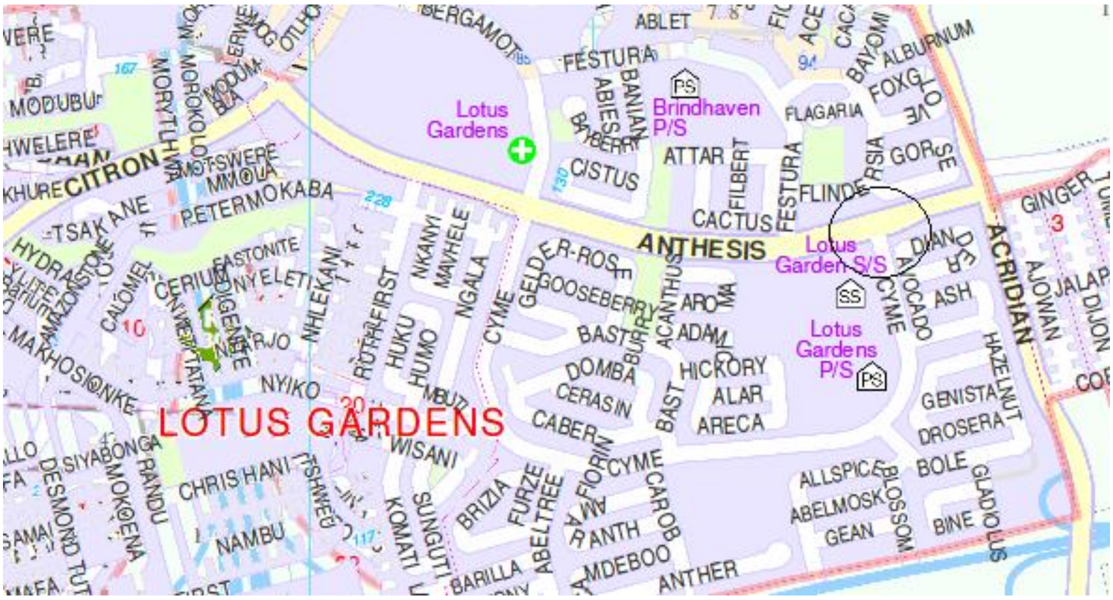


Map B16: Hans Strijdom Drive and Boeing Street Intersection



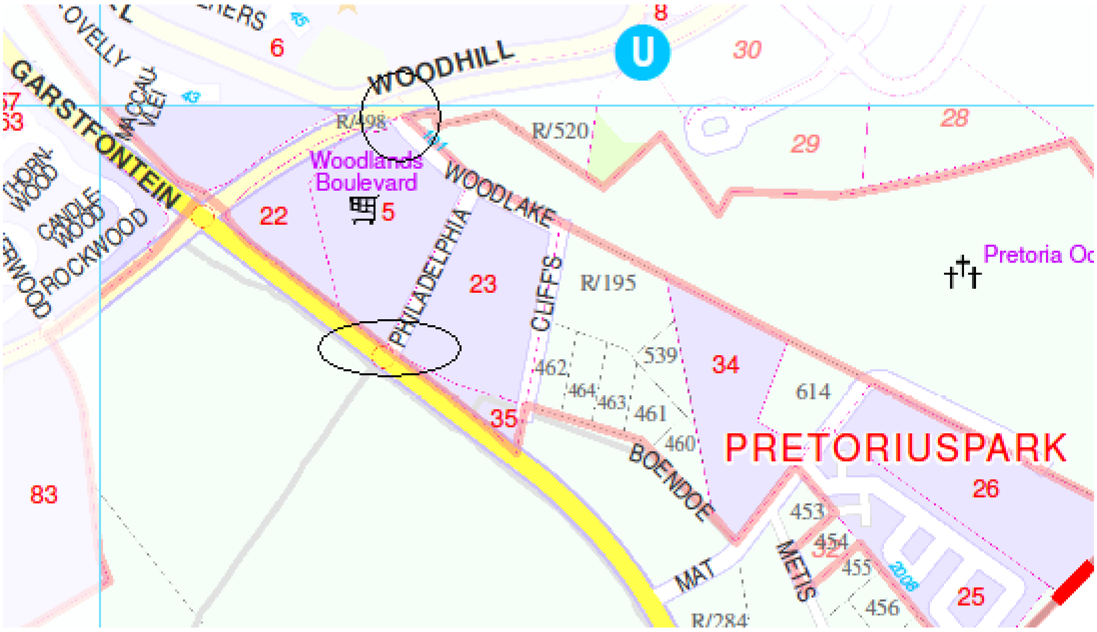
Map B17: Soutpansberg Road and Wren Street Intersection

Map B18: Daan de Wet Nel Drive and Rene Road Intersection



Map B19: Anthesis Street and Cyme Crescent Intersection

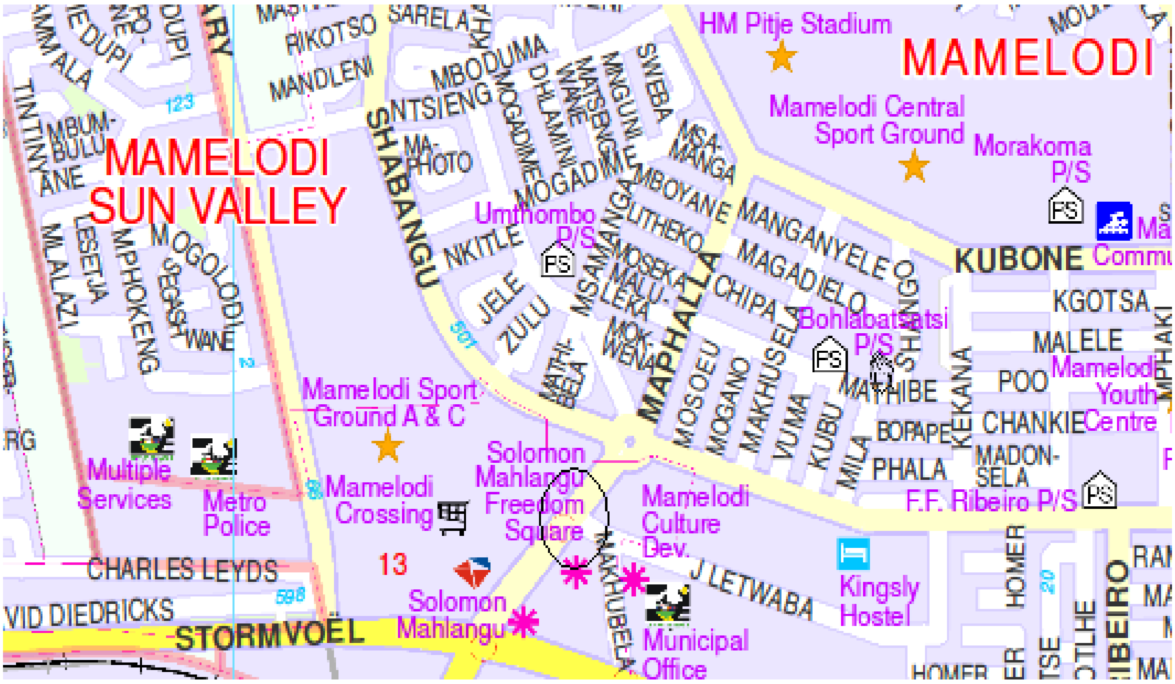
Retail Development Intersection



Map B20: Garstfontein Road and Philadelphia Avenue Intersection

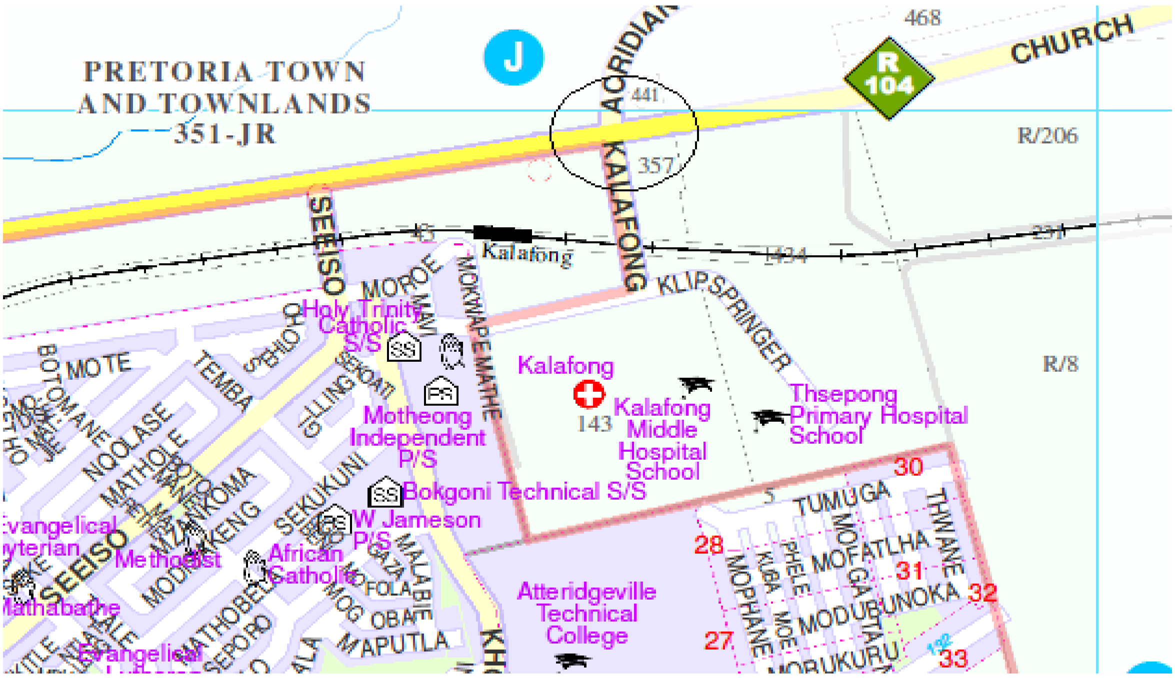
De Villebois Mareuil Drive and Woodlake Boulevard Intersection

Map B21: Heinrich Drive and Madelief Avenue (Angelier) Intersection



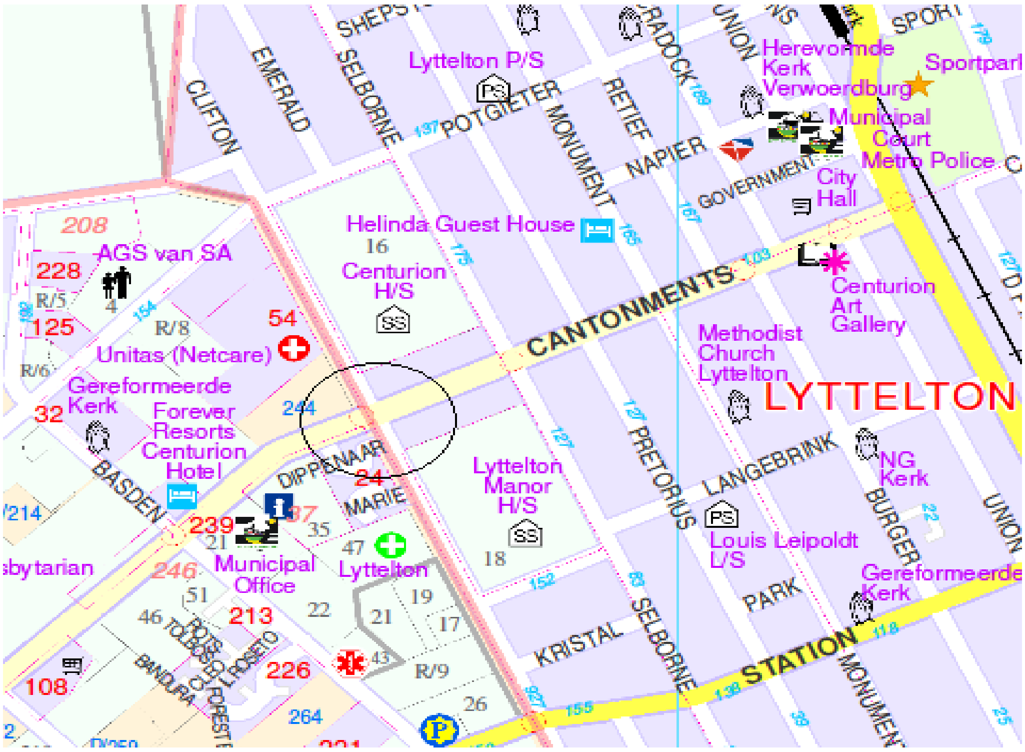
Map B22: Maphalla Drive and J Letwaba Street Intersection

Medical: Hospitals Developments Intersections

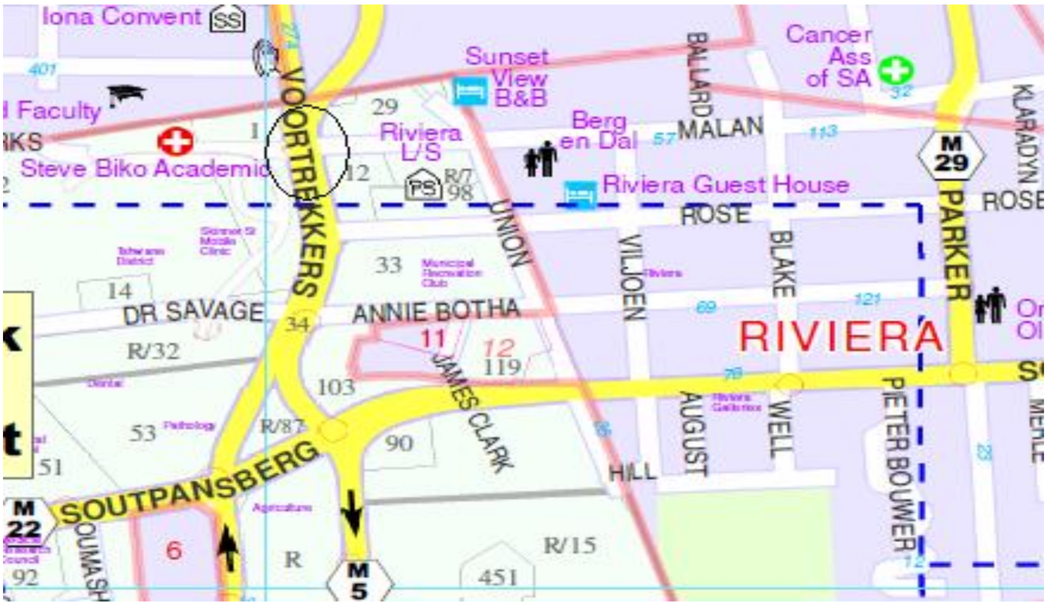


Map B23: Church and Kalafong Street Hospital Intersection

Map B24: Simon Vermooten Drive and Lynnwood Intersection

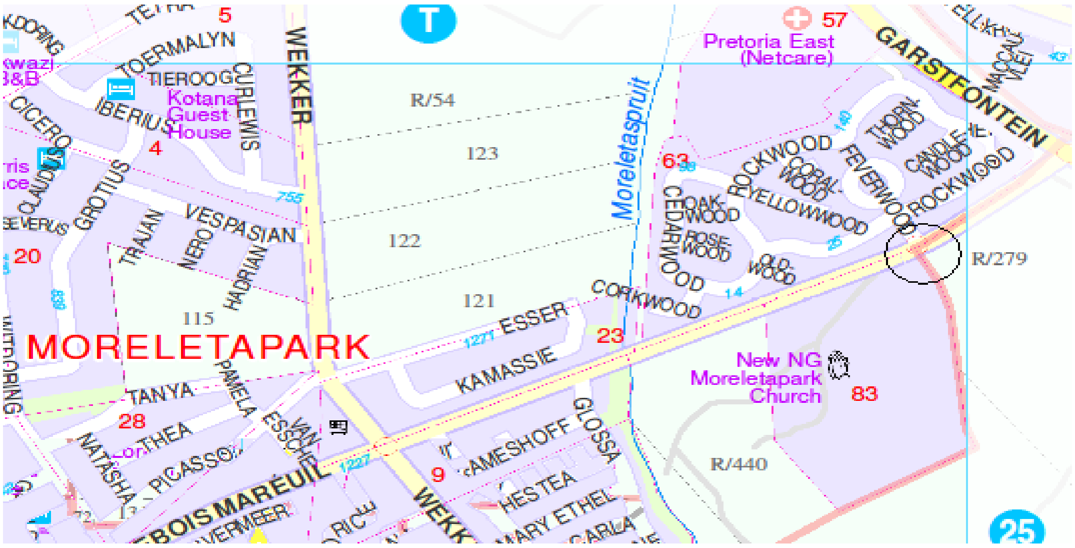


Map B25: Cliffton Avenue and Cantonment Road Intersection

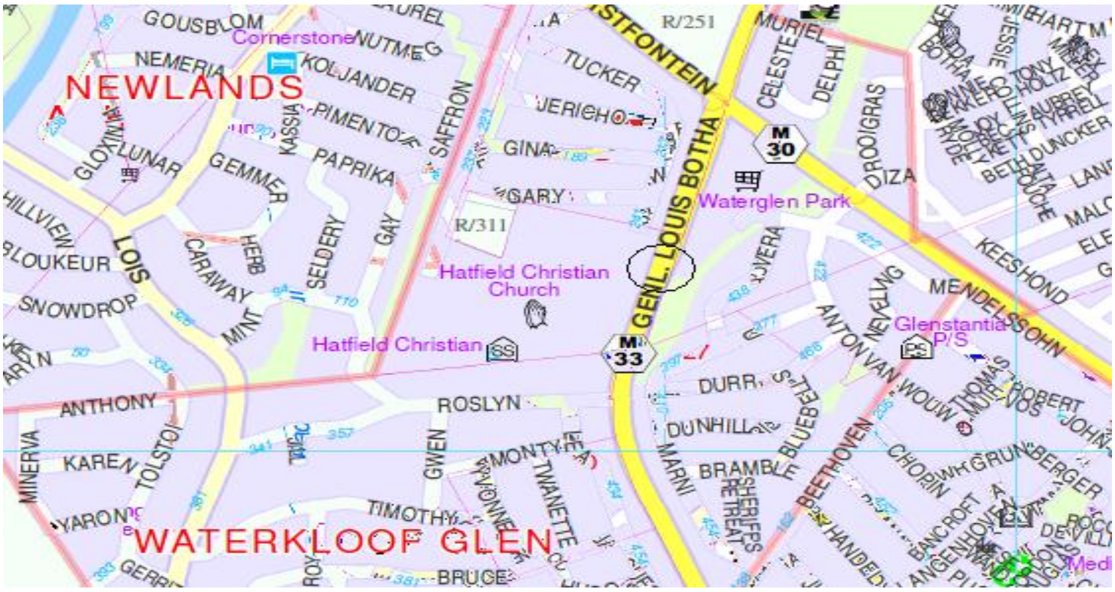


Map B26: Voortrekker Road and Malan Street Intersection

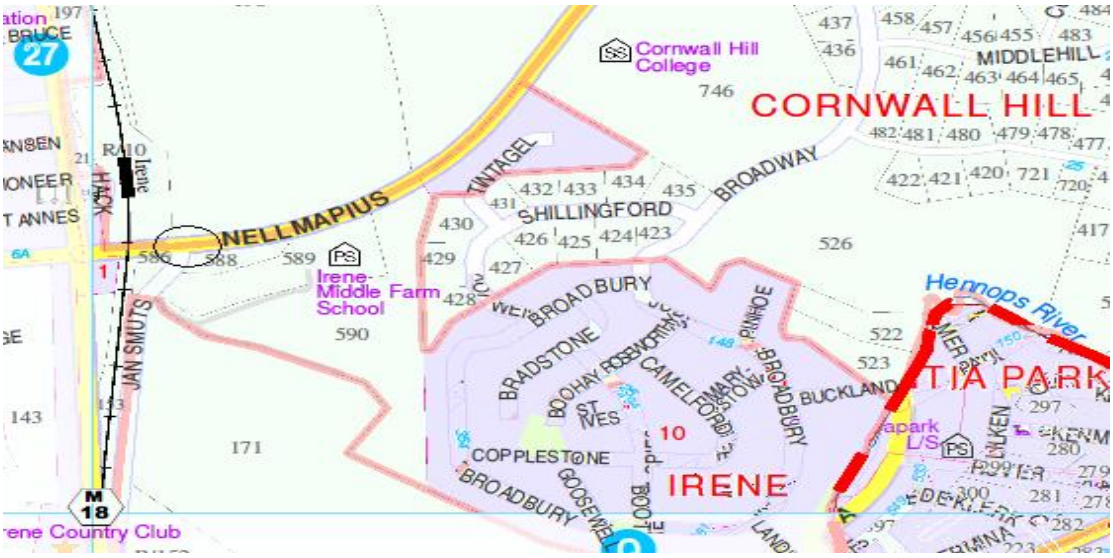
Places of Worship Intersection



Map B27: De Villebois Mareuil Drive and Feverwood Road Intersection



Map B28: Genl. Louis Botha Drive and Hatfield Church Entrance Intersection



Map B29: Nellmapius Drive and Jan Smuts Avenue Intersection

APPENDIX C

Table C1: STATA Data Analysis Results

```
                                          ___  ____  ____  ____  ____(R)
                                         /__    /   ____/   /   ____/
                                        ___/   /   /___/   /   /___/
                                          Statistics/Data Analysis

                                             User: MH Phahlane
                 Project: Effect of land-use change on traffic PHF{space -18}

  ___  ____  ____  ____  ____ (R)
 /__    /   ____/   /   ____/
___/   /   /___/   /   /___/   11.0   Copyright 1984-2009
  Statistics/Data Analysis            StataCorp
                                      4905 Lakeway Drive
     Special Edition                  College Station, Texas 77845 USA
                                      800-STATA-PC        http://www.stata.com
                                      979-696-4600        stata@stata.com
                                      979-696-4601 (fax)

30-student Stata lab perpetual license:
       Serial number:  40110557797
         Licensed to:  Zekele Worku
                       School of Business

Notes:
      1.  (/m# option or -set memory-) 50.00 MB allocated to data
      2.  (/v# option or -set maxvar-) 5000 maximum variables
Checking http://www.stata.com for update... connection timed out -- see help r(2) for
> troubleshooting
unable to check for update; verify Internet settings are correct.

. use "\\smiicoryf007\private\Roads & Stormwater\herbertp\Herbert\M-Tech\thesis\Chapte
> r 4\RES.dta", clear

. list

     +-----------------------------------------------------------------------+
  1. |                         intersection | approach |         peakperiod |
     |   Church Street and Strachan Street |    North | 06:00 to 09:00     |
     |-------------------+----------+------------+--------+-----------------|
     |          peakhour |      phv |      minpv |    phf |        inboun~t |
     |    06:30 to 07:30 |     1846 |        475 |    .97 |             18% |
     +-----------------------------------------------------------------------+

     +-----------------------------------------------------------------------+
  2. |                         intersection | approach |         peakperiod |
     |                                      |          | 15:30 to 18:00     |
     |-------------------+----------+------------+--------+-----------------|
     |          peakhour |      phv |      minpv |    phf |        inboun~t |
     |    16:45 to 17:45 |      904 |        242 |    .93 |             63% |
     +-----------------------------------------------------------------------+

     +-----------------------------------------------------------------------+
  3. |                         intersection | approach |         peakperiod |
     | Zambezi Drive and Zambezi Estate Street |  North | 06:00 to 09:00     |
     |-------------------+----------+------------+--------+-----------------|
     |          peakhour |      phv |      minpv |    phf |        inboun~t |
     |    06:45 to 07:45 |      350 |         98 |    .89 |             40% |
     +-----------------------------------------------------------------------+

     +-----------------------------------------------------------------------+
  4. |                         intersection | approach |         peakperiod |
     |                                      |          | 15:30 to 18:00     |
     |-------------------+----------+------------+--------+-----------------|
     |          peakhour |      phv |      minpv |    phf |        inboun~t |
     |    16:00 to 17:00 |      332 |         94 |    .88 |             53% |
     +-----------------------------------------------------------------------+

     +-----------------------------------------------------------------------+
  5. |                         intersection | approach |         peakperiod |
     |      Brits Road and Doreen Avenue    |    South | 06:00 to 09:00     |
     |-------------------+----------+------------+--------+-----------------|
     |          peakhour |      phv |      minpv |    phf |        inboun~t |
     |    06:30 to 07:30 |      266 |         78 |    .85 |             38% |
     +-----------------------------------------------------------------------+
```

6.

intersection	approach	peakperiod
		15:30 to 18:00

peakhour	phv	minpv	phf	inboun~t
15:45 to 16:45	267	74	.9	57%

7.

intersection	approach	peakperiod
Hebron Road and Umphafa Street	South	06:00 to 09:00

peakhour	phv	minpv	phf	inboun~t
06:00 to 07:00	719	210	.86	36%

8.

intersection	approach	peakperiod
		15:30 to 18:00

peakhour	phv	minpv	phf	inboun~t
06:15 to 07:15	765	210	.91	63%

9.

intersection	approach	peakperiod
	North	06:00 to 09:00

peakhour	phv	minpv	phf	inboun~t
06:00 to 07:00	283	108	.66	35%

10.

intersection	approach	peakperiod
		15:30 to 18:00

peakhour	phv	minpv	phf	inboun~t
06:15 to 07:15	176	55	.8	68%

11.

intersection	approach	peakperiod
Cura Avenue and Stellenberg Road	North	06:00 to 09:00

peakhour	phv	minpv	phf	inboun~t
06:45 to 07:45	252	84	.75	15%

12.

intersection	approach	peakperiod
		15:30 to 18:00

peakhour	phv	minpv	phf	inboun~t
16:30 to 17:30	168	49	.86	71%

13.

intersection	approach	peakperiod
Stonewall Boulevard and Old Farm Road	North	06:00 to 09:00

peakhour	phv	minpv	phf	inboun~t
07:00 to 08:00	447	129	.87	21%

14.

intersection	approach	peakperiod

peakhour	phv	minpv	phf	inboun~t
	.	.	.	

15.

intersection			approach	peakperiod 15:30 to 18:00
peakhour 16:45 to 17:45	phv 584	minpv 177	phf .83	inboun~t 69%

16.

intersection Old Farm Road and Hans Strijdom Drive			approach East	peakperiod 06:00 to 09:00
peakhour 07:00 to 08:00	phv 1531	minpv 435	phf .88	inboun~t 29%

17.

intersection			approach	peakperiod 15:30 to 18:00
peakhour 16:00 to 17:00	phv 1561	minpv 423	phf .92	inboun~t 52%

18.

intersection Witch Hazel Avenue and Eco-park Boulevard			approach South	peakperiod 06:00 to 09:00
peakhour 07:00 to 08:00	phv 402	minpv 113	phf .89	inboun~t 12%

19.

intersection			approach	peakperiod 15:30 to 18:00
peakhour 17:00 to 18:00	phv 445	minpv 138	phf .81	inboun~t 62%

20.

intersection John Vorster and Karee Street			approach East	peakperiod 06:00 to 09:00
peakhour 07:00 to 08:00	phv 218	minpv 63	phf .86	inboun~t 24%

21.

intersection			approach	peakperiod 15:30 to 18:00
peakhour 16:45 to 17:45	phv 208	minpv 65	phf .8	inboun~t 60%

```
. summarize phv minpv phf
```

Variable	Obs	Mean	Std. Dev.	Min	Max
phv	20	586.2	502.8359	168	1846
minpv	20	166	132.0977	49	475
phf	20	.856	.0687788	.66	.97

. tabulate phf, summarize (phf)

PHF	Summary of PHF Mean	Std. Dev.	Freq.
.66	.66000003	0	1
.75	.75	0	1
.8	.80000001	0	2
.81	.81	0	1
.83	.82999998	0	1
.85	.85000002	0	1
.86	.86000001	0	3
.87	.87	0	1
.88	.88	0	2
.89	.88999999	0	2
.9	.89999998	0	1
.91	.91000003	0	1
.92	.92000002	0	1
.93	.93000001	0	1
.97	.97000003	0	1
Total	.85600001	.06877882	20

. tabulate peakhour

Peak Hour	Freq.	Percent	Cum.
06:00 to 07:00	2	10.00	10.00
06:15 to 07:15	2	10.00	20.00
06:30 to 07:30	2	10.00	30.00
06:45 to 07:45	2	10.00	40.00
07:00 to 08:00	4	20.00	60.00
15:45 to 16:45	1	5.00	65.00
16:00 to 17:00	2	10.00	75.00
16:30 to 17:30	1	5.00	80.00
16:45 to 17:45	3	15.00	95.00
17:00 to 18:00	1	5.00	100.00
Total	20	100.00	

. tabulate phf inboundsplit

PHF	Inbound Split 12%	15%	18%	21%	24%	Total
.66	0	0	0	0	0	1
.75	0	1	0	0	0	1
.8	0	0	0	0	0	2
.81	0	0	0	0	0	1
.83	0	0	0	0	0	1
.85	0	0	0	0	0	1
.86	0	0	0	0	1	3
.87	0	0	0	1	0	1
.88	0	0	0	0	0	2
.89	1	0	0	0	0	2
.9	0	0	0	0	0	1
.91	0	0	0	0	0	1
.92	0	0	0	0	0	1
.93	0	0	0	0	0	1
.97	0	0	1	0	0	1
Total	1	1	1	1	1	20

PHF	Inbound Split 29%	35%	36%	38%	40%	Total
.66	0	1	0	0	0	1
.75	0	0	0	0	0	1
.8	0	0	0	0	0	2
.81	0	0	0	0	0	1
.83	0	0	0	0	0	1
.85	0	0	0	1	0	1
.86	0	0	1	0	0	3
.87	0	0	0	0	0	1
.88	1	0	0	0	0	2
.89	0	0	0	0	1	2
.9	0	0	0	0	0	1
.91	0	0	0	0	0	1
.92	0	0	0	0	0	1
.93	0	0	0	0	0	1
.97	0	0	0	0	0	1
Total	1	1	1	1	1	20

PHF	Inbound Split 52%	53%	57%	60%	62%	Total
.66	0	0	0	0	0	1
.75	0	0	0	0	0	1
.8	0	0	0	1	0	2
.81	0	0	0	0	1	1
.83	0	0	0	0	0	1
.85	0	0	0	0	0	1
.86	0	0	0	0	0	3
.87	0	0	0	0	0	1
.88	0	1	0	0	0	2
.89	0	0	0	0	0	2
.9	0	0	1	0	0	1
.91	0	0	0	0	0	1
.92	1	0	0	0	0	1
.93	0	0	0	0	0	1
.97	0	0	0	0	0	1
Total	1	1	1	1	1	20

PHF	Inbound Split 63%	68%	69%	71%	Total
.66	0	0	0	0	1
.75	0	0	0	0	1
.8	0	1	0	0	2
.81	0	0	0	0	1
.83	0	0	1	0	1
.85	0	0	0	0	1
.86	0	0	0	1	3
.87	0	0	0	0	1
.88	0	0	0	0	2
.89	0	0	0	0	2
.9	0	0	0	0	1
.91	1	0	0	0	1
.92	0	0	0	0	1
.93	1	0	0	0	1
.97	0	0	0	0	1
Total	2	1	1	1	20

APPENDIX D

Table D1: SIDRA Intersection Capacity Analysis Results, 0.86 PHF

Brits Road and Doreen Avenue Intersection

New Site
Signals - Fixed Time   Cycle Time = 70 seconds (User-Given Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Doreen Avenue											
1	L	37	2.0	0.652	30.3	LOS C	6.5	46.2	0.88	0.88	33.4
2	T	79	2.0	0.652	22.1	LOS C	6.5	46.2	0.88	0.79	34.0
3	R	92	2.0	0.652	30.4	LOS C	6.5	46.2	0.88	0.89	33.3
Approach		208	2.0	0.652	27.2	LOS C	6.5	46.2	0.88	0.85	33.6
East: Brits Road											
4	L	40	2.0	0.505	22.8	LOS C	11.3	80.2	0.75	0.91	38.9
5	T	426	2.0	0.505	14.5	LOS B	11.3	80.2	0.75	0.66	40.5
6	R	173	2.0	0.737	40.7	LOS D	6.3	45.1	0.98	0.91	28.2
Approach		638	2.0	0.737	22.1	LOS C	11.3	80.2	0.82	0.74	36.2
North: Doreen Avenue											
7	L	352	2.0	0.716	30.0	LOS C	14.1	100.4	0.92	0.88	33.1
8	T	52	2.0	0.716	21.8	LOS C	14.1	100.4	0.92	0.82	33.6
9	R	52	2.0	0.716	30.1	LOS C	14.1	100.4	0.92	0.88	33.0
Approach		457	2.0	0.716	29.1	LOS C	14.1	100.4	0.92	0.87	33.1
West: Brits Road											
10	L	29	2.0	0.660	24.3	LOS C	16.3	116.0	0.83	0.92	38.2
11	T	580	2.0	0.660	16.0	LOS B	16.3	116.0	0.83	0.74	39.3
12	R	37	2.0	0.168	28.3	LOS C	1.0	6.8	0.76	0.74	33.6
Approach		647	2.0	0.660	17.1	LOS B	16.3	116.0	0.83	0.75	38.9
All Vehicles		1950	2.0	0.737	22.6	LOS C	16.3	116.0	0.85	0.79	35.9

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

Processed: 12 January 2012 05:27:00 PM
SIDRA INTERSECTION 5.1.8.2059

Project: C:\Documents and Settings\herbertp\Desktop\M-Tech\thesis\Chapter 4\Sidra\Res\Hebron Road and Doreen Avenue AM 0.86.sip
8001169, VAAL UNIVERSITY OF TECHNOLOGY, SINGLE

SIDRA INTERSECTION

Table D2: SIDRA Intersection Capacity Analysis Results, 0.92 PHF

Brits Road and Doreen Avenue Intersection

New Site
Signals - Fixed Time   Cycle Time = 70 seconds (User-Given Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Doreen Avenue											
1	L	35	2.0	0.548	27.9	LOS C	5.5	39.2	0.84	0.84	34.6
2	T	74	2.0	0.548	19.6	LOS B	5.5	39.2	0.84	0.71	35.5
3	R	86	2.0	0.548	28.0	LOS C	5.5	39.2	0.84	0.84	34.6
Approach		195	2.0	0.548	24.8	LOS C	5.5	39.2	0.84	0.79	34.9
East: Brits Road											
4	L	37	2.0	0.472	22.5	LOS C	10.3	73.5	0.74	0.91	39.0
5	T	398	2.0	0.472	14.2	LOS B	10.3	73.5	0.74	0.64	40.8
6	R	162	2.0	0.628	35.8	LOS D	5.4	38.1	0.94	0.85	30.1
Approach		597	2.0	0.628	20.6	LOS C	10.3	73.5	0.79	0.72	37.1
North: Doreen Avenue											
7	L	329	2.0	0.657	28.3	LOS C	12.4	88.1	0.89	0.85	33.9
8	T	49	2.0	0.657	20.1	LOS C	12.4	88.1	0.89	0.77	34.6
9	R	49	2.0	0.657	28.5	LOS C	12.4	88.1	0.89	0.85	33.9
Approach		427	2.0	0.657	27.4	LOS C	12.4	88.1	0.89	0.84	34.0
West: Brits Road											
10	L	27	2.0	0.617	23.8	LOS C	14.8	105.4	0.81	0.92	38.4
11	T	542	2.0	0.617	15.6	LOS B	14.8	105.4	0.81	0.72	39.7
12	R	35	2.0	0.154	27.4	LOS C	0.9	6.2	0.74	0.74	34.1
Approach		604	2.0	0.617	16.6	LOS B	14.8	105.4	0.81	0.73	39.3
All Vehicles		1823	2.0	0.657	21.3	LOS C	14.8	105.4	0.82	0.76	36.8

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

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Table D3: SIDRA Intersection Capacity Analysis Results, 0.95 PHF

Brits Road and Doreen Avenue Intersection

New Site
Signals - Fixed Time Cycle Time = 70 seconds (User-Given Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Doreen Avenue											
1	L	34	2.0	0.478	26.4	LOS C	5.1	36.0	0.80	0.83	35.4
2	T	72	2.0	0.478	18.2	LOS B	5.1	36.0	0.80	0.68	36.5
3	R	83	2.0	0.478	26.5	LOS C	5.1	36.0	0.80	0.84	35.4
Approach		188	2.0	0.478	23.3	LOS C	5.1	36.0	0.80	0.78	35.8
East: Brits Road											
4	L	36	2.0	0.472	23.1	LOS C	10.2	72.5	0.75	0.91	38.6
5	T	385	2.0	0.472	14.9	LOS B	10.2	72.5	0.75	0.65	40.3
6	R	157	2.0	0.617	36.3	LOS D	5.2	37.0	0.94	0.84	29.9
Approach		578	2.0	0.617	21.2	LOS C	10.2	72.5	0.80	0.72	36.7
North: Doreen Avenue											
7	L	319	2.0	0.605	27.1	LOS C	11.5	82.0	0.86	0.84	34.6
8	T	47	2.0	0.605	18.9	LOS B	11.5	82.0	0.86	0.74	35.4
9	R	47	2.0	0.605	27.2	LOS C	11.5	82.0	0.86	0.85	34.6
Approach		414	2.0	0.605	26.2	LOS C	11.5	82.0	0.86	0.83	34.7
West: Brits Road											
10	L	26	2.0	0.617	24.5	LOS C	14.5	103.6	0.82	0.91	38.0
11	T	525	2.0	0.617	16.2	LOS B	14.5	103.6	0.82	0.72	39.2
12	R	34	2.0	0.151	28.2	LOS C	0.9	6.1	0.75	0.74	33.7
Approach		585	2.0	0.617	17.3	LOS B	14.5	103.6	0.82	0.73	38.8
All Vehicles		1765	2.0	0.617	21.3	LOS C	14.5	103.6	0.82	0.76	36.8

Level of Service (LOS) Method: Delay & v/c (HCM 2010).
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
SIDRA Standard Delay Model used.

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