Traffic Circulation and Parking Facilities in UTP Campus

by

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Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Civil Engineering)

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CERTIFICATION OF APPROVAL

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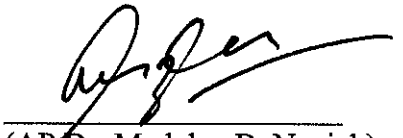

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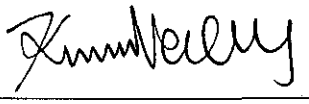
TRONOH, PERAK

December 2004

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



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ABSTRACT

The objective of the project is to study the traffic pattern in the campus, and to determine the amount of parking spaces needed. Once these data is collected and analyzed, a projection for future forecast would be made to gain a foothold on the expected amount of traffic. The results of these analyses would be used as the basis to accomplish the most important and beneficial objective of the project, which is to propose a traffic circulation system and traffic management system to ensure comfort and safety of the campus road users.

The bulk of the literature review was done on various traffic circulation concepts and the relevant traffic studies, parking designs and studies, as well as some common types of traffic management measures. The subsequent section of the report elaborates on the methodology and the project work performed. The main tasks performed were information gathering, conducting traffic an parking studies, subsequent analysis and later devising a new traffic management scheme to ensure convenience of students and staffs.

The results of the project are clearly discussed in Section 4.0 of Results and Discussion. Several new parking facilities were suggested for the hostels, as well as some other at the new academic buildings. Several prudent traffic management measures were implemented, covering aspects of safety, increasing accessibility and improved traffic circulation. The main measures suggested were imposing limits to amount of student vehicles, converting some roads to one way streets, implementation of a bus/shuttle service system and finally proper enforcement of this scheme.

The final section of this report includes various recommendations that could have been done to improve this project, as well as some other suggestions for future work expansion and continuation.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Traffic studies involve data collection of the trends in traffic circulation, i.e. volume, demand, capacity, travel time, speed, delay and parking. The traffic studies are important to understand the needs and choices of the public, to investigate trends over time and to assess effectiveness of improvements.

UTP campus transportation network consist mostly of two lane two way roads. This transportation network has done well in the past to cater for the needs and demand of the traffic in the campus. However, due to the increase of vehicles and new traffic demands, the traffic circulation in the area needs to be reassessed. Parking facilities are also located at various locations around the campus, such as lecture halls, tutorial buildings, administrative offices, and also around the hostel area.

Recent observation of the traffic flow in the campus concurs that there is an increase of vehicles maneuvering. This is mainly due to the influx of undergraduates vehicles over the past 2 years, as all undergraduates have been relocated to stay in campus after new hostel facilities were constructed. Besides, there is also an increase in the number of students having their own transportation. This has resulted in an increase in traffic circulation in the campus, coupled with parking limitations especially around the hostel area.

The reassessment of traffic circulation and parking adequacy underlines the main aim of the project. Various traffic surveys and parking studies would be used as basis for analysis. A modeling of the current and future traffic trends in the campus would be done. With the resource of these

new data, a new traffic management system would be developed to cater for the current and future needs of the campus, ensuring smooth flow of traffic and safer driving and maneuvering in the campus.

1.2 Problem Statement

1.2.1 Problem Identification

Traffic circulation issues in the campus have raised some concerns among the staff and students. Students and staff do face some difficulties to maneuver around the campus especially during peak hours of traffic flow. This is partly due to the fact that the number of vehicles on UTP campus was under estimated during the planning stages.

Matters become deplorable during special function and occasions held at the university such as Convocation Fair. The influx of traffic into the university has in past events, caused traffic congestions. Furthermore, parking spaces in the campus are inadequate, especially around the hostels. These lack of parking spaces forced car users to park their vehicle indiscriminately causing more traffic congestion.

With the completion of the new campus, the traffic demands have changed from previous years. Vehicles frequent the new campus more often and resulting in a shift of demand to these areas. With the proposed new blocks of hostels adjacent to villages 3&4, the traffic generation in the campus would mostly originate from this area, and would cause a change in traffic generation and distribution in the campus. This change will also affect the adequacy of parking facilities. The new hostels have to be provided with adequate parking facilities, which at the moment is lacking. Other parking areas may become redundant due to shift of hostels and other administrative buildings to new locations.

These problems faced by the campus at the moment on the traffic and parking facilities needs to be analyzed soon to mitigate severe traffic problems and parking inadequateness in the near future.

1.2.2 Significance of the Project

The project will eventually help provide a suggested approach of a New Traffic Management System for the implementation in UTP. This Traffic Management System will integrate the parking and traffic solutions in its system, while ensuring comfort and convenience to the population in UTP.

1.3 Objectives and Scope of Study

1.3.1 Relevancy of the Project

The project is relevant due to the existing problem of traffic and parking in the university. For parking, the initial campus design showed that the number of parking spaces were greatly underestimated resulting in cars illegally parked. This project aims at studying and finding a solution to the parking problems. Furthermore, there are new hostels and academic offices that are going to be constructed under the Full Development Campus Plan, and it is timely to reassess the parking allocation for these new buildings.

The campus at the moment does not have a traffic management system that provides convenient transportation service around the campus. This is another area that is looked into. The campus area is undergoing continuous development, and the distance between the hostels and the new academic blocks are of considerable distance. Providing a

suggested solution may lead UTP to consider the implementation of this system, if proven useful.

1.3.2 Feasibility of the project within the Scope and Timeframe

For the successful completion of this project, the following objective needs to be met:

i. To study the traffic pattern at UTP campus
ii. To design better traffic circulation system in the campus
iii. To determine parking space requirements and optimize the available space within the campus
iv. To propose traffic management scheme to ensure safety and comfort of campus road users

CHAPTER 2

LITERATURE REVIEW/THEORY

In this chapter the general concept behind traffic circulation, parking facilities and traffic management systems were reviewed. Considerable amount of time was allocated to obtain information and materials that is relevant to the project. These literature materials were obtained from various book references related to traffic engineering.

2.1 Traffic Circulation

Most measurements in traffic engineering involve counting vehicles and people. These counts produce estimates such as volume and flow rate, demand and capacity. Hence, research was done on the various concepts and the correct procedures of performing traffic surveys for data gathering and analysis. The succinct of the materials reviewed were on traffic flow characteristics, volume characteristics, applicable traffic surveys, origin destination studies and forecasting of travel demand.

2.1.1 Traffic Flow Characteristics

The traffic flow theory involves the use of mathematical relationships such as flow, density and speed. These relationships are vital in planning, designing and evaluating the effectiveness of implementing traffic improvement measures. Flow can be mathematically equated as the hourly rate at which vehicles pass a point on a road or highway during a time period of less than 1 hour. (Garber, 2002)

This very basic concept of flow is the fundamental principal for all the other concepts related to traffic circulation such as density (k), speed (u), time mean speed ($\bar{u}_t$), space mean speed ($\bar{u}_s$), time headway (h), and space headway (d). In brief, the relationship between of flow-density can be summed up in the following equation. (Garber, 2002)

$$\text{flow } (q) = \text{density } (k) \times \text{space mean speed } (\bar{u}_s)$$

2.1.2 Traffic Volume Studies

Traffic volume studies are conducted to collect data on the number of vehicles that pass a point on a highway or road during a specified time period. The time period can vary from as little as 15 min to a year, depending on the anticipated use of the data. The data may also be put into subclass which may include directional movement, occupancy rate, vehicle classification, and pedestrian age. There are two main methods of conducting volume count, the manual and automatic method. (Khisty, 2003)

2.1.2.1 Manual Method

This method involves one or more persons recording observed vehicles using a counter. The main disadvantages of the manual count is that it is labour intensive and can therefore be expensive, it is also subject to the limitation of the human factor, and hence it cannot be used for long periods of counting.

2.1.2.2 Automatic Method

Some automatic counters use a counting method that involves the laying of the surface detectors (such as pneumatic road tubes) or subsurface detectors (such as magnetic or electric contact devices) on the road. These detect the passing vehicle

and transmit the information to a recorder, which is connected to the detector at the side of the road.

2.1.3 Forecasting Travel Demand

Literature on demand forecasting and trip generation was researched due to the fact that the traveling conditions would vary over the years in the campus. Travel forecasting is an integral part of site development and traffic engineering studies. The demand forecasting process includes trip generation and trip distribution.

2.1.3.1 Trip Generation

Trip generation is the process of determining the number of trips that will begin or end in each traffic zone within a study area. These analyses has two functions which are to develop a relationship between trip end production and land use, and to use the relationship developed to estimate the number of trips generated in the future (Roess, 2004). In the case of this project, trip generation analysis would be done to estimate the number of trips generated from the hostels, as this is the main source of traffic generation. Furthermore, in the future, all students will be located in the same hostel area. Hence the trip generation would be used to forecast future traffic from this hostel.

2.1.3.2 Trip Distribution

Trip distribution is a process by which the trips generated in one zone are allocated to other zones in the study area. Many models for trips distribution are made available such as the gravity model and growth factor models (Roess, 2004). In the case of the project, these models can be applied for the analysis of trip distributions. From the data gathered from

trip generation, the trip distribution for the current and future traffic routing can be analyzed.

2.2 Parking Facilities

The most important parameter in parking is the determination of how many spaces required for a particular development, and where it should be located. These requirements lead to locally based zoning regulations on minimum number of spaces that need to be provided when a development is built. The need for parking spaces depends upon many factors such as land use, general density of people, and quality of public transportation. Literature review for parking facilities covered various subjects of common parking studies and characteristics, parking analysis after acquiring data, and several parking design dimensions most commonly used.

2.2.1 Parking Studies and Characteristics

A comprehensive parking study involves the following:

i. creating an inventory of existing parking facilities,
ii. collection of parking data, parking turnover, and parking duration,
iii. identification of parking generators
iv. collection of information on parking demand.

Before conducting the parking analysis, a study is done on the overall assessment of parking needs and its existing parking supply. These preliminary studies would include observation on the number of parking spaces and its locations, time restriction on use of parking spaces, and the type of parking facilities provided. Parking facilities can be divided into two main groups which are on-street ad off-street parking facilities.

2.2.1.1 On-Street Parking Facilities

This parking facility involves the use of the area around the curb on both sides of the street. Also known as curb facilities, these parking area would require proper road signage and road markings to indicate the parking space.

2.2.1.2 Off-Street Parking

This parking facility involves dedicated surface lots for parking. This may include multi-story car parks, parking lots, garages, etc.

2.2.1 Parking Design

The geometric design of parking facilities mainly involves the dimensioning and arranging of parking bays to provide safe and easy access, without restricting flow of traffic on traveling lanes.

2.2.2.1 Design of On-Street Parking Facilities

The design of on-street parking facilities which is also referred to as curb parking have various configurations. The most common of the configurations are parallel, 30°, 45°, 60°, and 90°. Parking bays that are inclined at angles to the curb can interfere with the movements of the traffic, and this have resulted in higher crash rates on sections on the road with angle parking rather than parallel parking.

2.2.2.2 Design of Off-Street Parking- Surface Car Parks

The main aim for designing off-street parking facilities is to obtain the maximum number of parking spaces. The various different parking layout analyzed indicates that the inclined 90° angle is the most efficient. For one way traffic flow on each aisle, the Herringbone Layout of Parking Stalls is employed.

2.3 Traffic Management System

Literature review on this subject was minimally done, as the bulk of this task would be done in the second half of the project. Materials reviewed for this subject were on the types of traffic management measures commonly applied to overcome traffic problems. These traffic management measures can be divided into four main categories (O' Flaherty, 1997).

2.3.1 Capacity Improvement

Capacity improvement refers to improving the traffic flow of roads. This can be done by upgrading the roads by providing more lanes. However, if widening of the road is not an option, other measures could be employed such as enforcing one way systems, tidal flow systems, restrictions on turning movements, closing side streets and improving traffic signals.

2.3.2 Priority Systems

These priority systems refer to giving priority to various modes of transport. This measure is usually done when traffic surveys suggest high amounts of these modes of transport accessing the transportation network. Some of the measures that could be implemented are having bus priority lanes, pedestrian walkways and cycling schemes. Ideally, footways, sidewalks and other pedestrian measures should be planned for education institutions like colleges and universities whereby walking is the most common form of transportation.

2.3.3 Restraint Measures

These refer to having a form of control over the traffic volume by imposing measures to reduce traffic into a particular area. These

measures are used especially in congested areas and in places with high traffic volume especially during peak hours. Some types of restraint measures are the implementation of parking fees, road pricing, and also controlled physical restrains. Controlled physical restraints are mainly used to reduce congestions at intersections.

2.3.4 Safety Measures

Safety measures are devised to reduce accidents rates and also to reduce accident risks present in a particular traffic network. These safety measures include controlling vehicle speed, providing pedestrian facility and creating proper road lighting and signage.

CHAPTER 3

METHODOLOGY/PROJECT WORK

3.1 Procedure Identification

Figure 3.1 summarizes the process flowchart of the project. Upon finalizing the topic selection, discussions were done with supervisor and relevant personnel to collect information. Contacts were made towards relevant departments for further assistance in obtaining data for the research of the project.

3.2 Information Gathering

Firstly, basic demographic information about the campus was obtained from Property Management and Maintenance Department of UTP. These overall layout plans show the campus's full development plans, including the proposed buildings and structures that have yet to be constructed. The purposes of these plans are:

i. To obtain overall overview of the campus layout
ii. To identify current and future road networks in the campus
iii. To identify current and future parking facilities in the campus

Information regarding amount of cars and motorcycles in UTP were obtained from the UTP Security Office. Information pertaining to number of students, and their projected intakes were obtained from the Students Services Department.

3.3 Parking Studies and Analysis

Preliminary parking studies and thereafter parking analysis were carried out. The main objectives of conducting these preliminary studies are:

i. To identify amount of parking spaces allocated at parking locations
ii. To identify parking trends in the campus
iii. To use the data gathered in performing analysis

3.3.1 Allocated Parking Bay Counts

The purpose of this count is to identify the amount of parking spaces allocated around the campus vicinity.

Tools Required

1. Writing Stationary
2. Counter

Procedure

1. Identify the locations of the parking facilities in the campus.
2. Determine the type of parking facility
3. Conduct counts on the number of parking space allocated

3.3.2 Parking Observations and Parking Peak Hour Demand

The purpose of this study is to identify the parking characteristics and trend around the campus. This observation will also assist in selecting the parking lots that needs further studies for the second half of the FYP.

Tools Required

1. Writing Stationary
2. Counter

Procedure

1. Conduct observation at the various parking
2. Identify the parking trend (amount of cars legally and illegally parked)
3. Record Data on Hourly Parking Demand
4. Observe for traffic hazards due to parking.

3.3.3 Parking Analysis

From the data gathered from the parking studies, various analyses to determine the parking adequacy, suitability, and peak hourly demand were conducted. The parking analysis was separated into 2 parts based on the parking purposes which were parking at residential colleges, and the other parking at academic, administration offices and other facilities in UTP.

3.3.3.1 Parking at Residential Colleges

The main purpose of this analysis is to determine the adequacy of parking lots for the amount of students in the residential colleges. Total amount of parking lots were obtained and analyzed with respect to the amount of students in the hostels. The ratio of total parking lots to total students per hostel was also analyzed. Amount of cars parked legally and illegally were used to determine the inadequacy of these parking lots. The ratio of total student cars to the total amount of students obtained from the information gathering process will assist in finding the amount of parking spaces that are lacking. Based on this information, the future parking plans which includes the 3 new villages can be devised for convenience and in line with the new traffic management system to be implemented.

3.3.3.2 Parking at Academic Offices and Administration Building

The main purpose of this analysis is to determine the peak hourly demand and adequacy of the parking spaces outside the residential college, where the demand of the parking lots are based on activity and not residential purposes. A projected estimation of amount of parking needed for staff and personnel per building was done, coupled with an estimated demand of students and vendors using those parking spaces. Furthermore, future parking analyses would have to cover for the academic buildings which have yet to be constructed

3.4 Traffic Studies and Analysis

Preliminary traffic surveys and observations were done during this first half of the FYP. The main objectives of conducting these preliminary studies are:

i. to identify amount of traffic trends in the campus
ii. to identify the locations of traffic congestion
iii. to use the data gathered in devising further traffic studies and analysis for the second half of FYP.

3.4.1 Traffic Observation

The purpose of this study is to identify the traffic trends around the campus. This observation will also assist in selecting the traffic studies that needs to be conducted in the second half of the FYP.

Tools Required

1. Writing Stationary

Procedure

1. Conduct observation at various roads during normal trips around the campus.
2. Identify traffic congestions
3. Observe for hazards caused by traffic

3.4.2 Traffic Volume Counts

Traffic volume counts were done at the 2 roundabout in UTP for the purpose of gathering traffic flow information. Roundabout 1, located at the residential colleges provides a reasonable flow characteristics at the hostel area, while at Roundabout 2 located near the UTP Main Hall provides traffic flow volume of cars entering and leaving UTP. Hourly volume counts were obtained for a period of several days.

Tools Required

1. Traffic Counter
2. Writing Stationary

Procedure

1. Record the amount of cars and motorcycle approaching and leaving the roundabout.
2. Observe for congestions and other traffic hazards at these locations.

3.4.3 Trip Generation Survey

The purpose of this trip generation survey is to determine the characteristics and frequency of the trips generated by the students in UTP. There are many factors that influence the trip generation rates. For this project, the parameters used to determine the characteristics were:

i. Trips Produced per Household
ii. Cars per Household
iii. Average Year of Study per Household

This data from the trip generation survey would be used to further assist in determination of future traffic routing in UTP.

Tools

1. Writing Stationary

Procedure

1. Select 30 random households of various villages.
2. Conduct survey on number of trips generated per household, and obtain information pertaining to their year of study and number of vehicles per household.
3. Tabulate the data and plot graphs indicating amount of trips per household, with respect to nunber of cars and average year of study for students.

3.4.4 Traffic Analysis

From the data gathered, further analyses for the traffic circulation in the campus were carried out. The analyses were divided into two main parts which were the current and future routing.

3.4.4.1 Current Routing

The traffic volume counts will be used to determine the flow of vehicles in the traffic routes in the campus. Peak hourly flows will be used to understand the flow characteristics, and also to determine the adequacy of the road system in the campus.

3.4.4.2 Future Routing

Based on the current routing characteristics, and the trip generation survey results, the future flow can be projected and hence determined. In the future, there would be new roads connecting to new buildings and offices around the campus, in line with the full development plan of UTP. These new roads could divert traffic from the current route,

and determination of the trip distribution for this future route is done.

3.5 Traffic Management System Analyses

Based on the data and analyses of both parking and traffic circulation, a new traffic management system and control will be implemented as part of upgrading the transportation services in UTP. There are many types of traffic management measures that could be implemented, hence the one that satisfies the urgent needs and demand of the transportation needs was addressed first.

For better effectiveness, and as part of creating a new master plan of traffic management and control system, the future parking lots, traffic circulation, and other traffic management measures was integrated together, in terms of planning and control.

Other types of traffic management measures to ensure transportation convenience in the campus was devised.

3.6 Process Flowchart

A process flow chart was developed in order to have a systematic approach in this study. The process flowchart is shown in Figure 3.1.

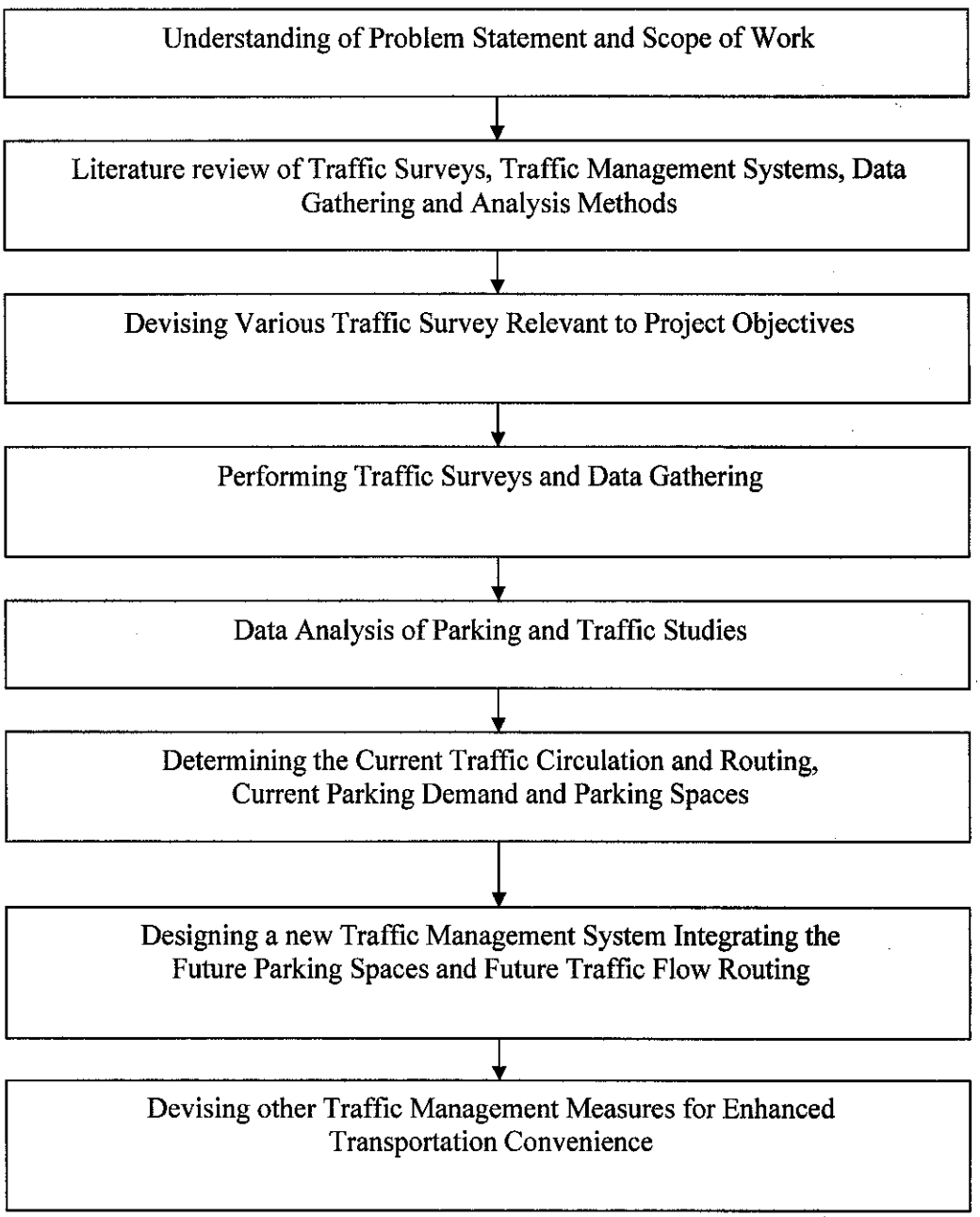

Figure 3.1: Project process flowchart.

CHAPTER 4

RESULTS AND DISCUSSIONS

The following are the results obtained from the traffic and parking studies conducted. Analysis of these data is also expressed in the form of tables, graphs and other relevant figures.

4.1 Campus Demographics

Table 4.1: Number of Cars and Motorcycles Stickers (2004/2005) issued by the Security Department of UTP

UTP VEHICLE STICKERS	TYPES OF VEHICLES	
	CARS	MOTOCYCLES
STUDENT	734	383
STAFF	606	173
VENDOR	76	52

The values in Table 4.1 indicate the amount of stickers issued, and it provides an indication of the number of vehicles in the campus. The amount of cars possess by students is much more than staffs and vendors. Cars also outnumber motorcycles for all three categories.

It should be noted however that the lecturers and other UTP staffs are allowed to register more than one car with the university, rendering the high amount of stickers compared to the number of staffs. Besides, vendors on the other hand, only contribute to the traffic circulation temporarily as they come and go depending on the duration of work in the campus.

4.2 Current Parking Data

The current parking data was obtained from parking studies and analysis. In Figure 4.1 the location of parking lots throughout the entire university is illustrated. Table 4.2 also shows the summary of the amount of legal parking for both car parking bays and motorcycle parking bays currently provided in UTP.

Table 4.2: Allocated Amount of Legal Parking Bays for Cars and Motorcycle

Location	Car Parking Bays	Motorcycle Parking Bays
Village 1	70	45
Village 2	84	115
Village 3	55	32
Village 4	148	78
Village 5	123	56
Parking Lot Pocket C	140	82
Parking Lot Library	128	74
Parking Lot Old Chemical Block	34	24
Old USM Building	384	176
Old Hostels	143	112
Administration Buildings	60	24
Sports Complex	90	38
Multipurpose Hall	56	18
Main Hall	332	125

Table 4.3 shows a summary of the amount of parking spaces for the residential college. The indication of the ratio of students per parking space clearly shows that not all the villages are given the same parking ratio, and some villages were provided with more parking spaces. The most obvious occurrence is the amount of parking space in village 3, which is very low compared to the population of students.

Table 4.3: Ratio of Students per Parking Space at the Hostel Village

Village	Parking Spaces	Max of Students	Ratio (Students Per Parking space
Village 1	70	600	8.57
Village 2	84	600	7.14
Village 3	55	852	15.5
Village 4	148	900	6.08
Village 5	123	684	5.56

Results of peak hour demand for parking at various locations are placed in Appendix 3. Table 4.4 shows the summary of existing peak hour parking demand at the various locations in UTP. The peak hour demand for the hostels clearly shows the inadequacy of parking spaces. All villages except village 1 indicate a shortage of car park. The new academic blocks have at the moment had access of parking spaces for both staffs and students usage. Car park at Pocket C however, has the largest excess capacity compared to other parking lots designed for other administrative buildings.

Table 4.4: Existing Peak Hour Demand of Parking Facilities

Location	Peak Hour Demand	Capacity (Veh/Hr)	Excess Capacity (Veh/Hr)
Administration Block	49	60	11
Old Chemical Building	91	34	-57
Carpark Library	84	128	44
Carpark Pocket C	21	140	119
Village 1	34	70	36
Village 2	104	84	-20
Village 3	190	55	-135
Village 4	228	148	-80
Village 5	144	123	-21

4.2.1 Parking Observations

The parking facilities provided in the campus is not equally distributed to the demand of the facilities. The analysis of the parking facilities is observed for three main areas of demand which are:

4.2.1.1 Hostel Parking Facilities

Village 3 & 4 – The parking lots allocated in this area are off-street parking facilities which are surface car parks. The parking bays allocated are of 90° angle. This hostel area contains the most demand for parking lots as the students living in this hostel are third year to final year students. Besides, this village contains the most concentration of students compared to the other hostels. The situation worsened when the sides of the road underwent landscape upgrading. This roadside curb used to be allowed for parking, although parking spaces were not officially allocated. Upon receiving numerous complaints, the fire access route between Village 4 and Village 3 were allowed for temporary parking.

As a result of the parking inadequacies in this hostel area, observations reveal that many cars have be parked illegally around this area such as on the road side curb, and even double parking at some places. This has induced many summonses to be issued to the students throughout the entire semester. In order to avoid summons, students resolve to park their cars at other parking spaces out of the way from the hostel such as in village 2.

Village 2 – The Parking Spaces allocate in this area are also off street parking facilities which are surface car parks of 90° bays. The parking facilities provided in this area seems to meet the demand of the students in this hostel. As most of

the students are second year students and not many of them have cars. However, due to the obvious lack of parking spaces in Village 3 & 4, cars from students in those villages also park their cars here, inducing lack of parking bays. As a result, illegal parking is found on the roadside curb and on the field in front of the hostel.

Village 1 – The parking spaces allocated here are also of off-street parking facilities which are surface car parks consisting of 90° angle and parallel bays. The parking spaces allocated here are more than adequate. This is due to the fact that not many students are staying in this hostel as most of them have been shifted to village 3 & 4.

Old hostels – This hostels include Propana, Metana, Etana , Duyung, Semarang and Baram blocks. Observations reveal more than adequate parking facilties due to the fact that the hostel is only occupied by first year students of which and only a few students have cars.

4.2.1.2 Old Campus Parking Facilities

Parking facilities for the old campus are evenly spread to the lecture halls, tutorial rooms and administration building. The only major concern for the old campus is the parking facility next to the old chemical faculty. During the day, this place is packed with parked cars as this area is the closest to the new campus. The 34 parking bays allocated is barely enough, resulting in illegal parking.

4.2.1.3 New Campus Parking Facilities

From the campus development plans, the new campus is to have four main parking areas. To date, only two of the parking lots have been constructed. Both parking lots (140 and 128 bays each) are adequate to contain the cars in this

area. The parking lots only contain 90° angle parking bays. The only complaint received is the parking lot next to Pocket C because this parking lot requires considerable amount of walking distance to the faculties.

3.3.4 Parking Analysis

Table 4.5 shows that the demand for parking facilities at the moment for the hostels is inadequate. This has resulted in illegal parking around the hostels, and the usage of the fire access route. The current ratio of cars per student is 5.45 and motorcycle per student is 10.5. This situation will certainly worsen in the future with increasing number of students, which will indirectly increase the amount of vehicle sin the university.

Table 4.5: Tabulated Amount of Inadequate Parking Spaces for Village Hostels

	Cars	**Motorcycle**
Amount of Vehicles	**734**	**383**
Amount of Parking Space allocation	**480**	**326**
Amount of Inadequate Parking Space	**254**	**57**

Table 4.6: Exiting Vehicle Distribution for Students

Number Of Students	**Number of Vehicles**	**%**
Cars		
4000	**734**	**18.4**
Motorcycle		
4000	**383**	**9.6**

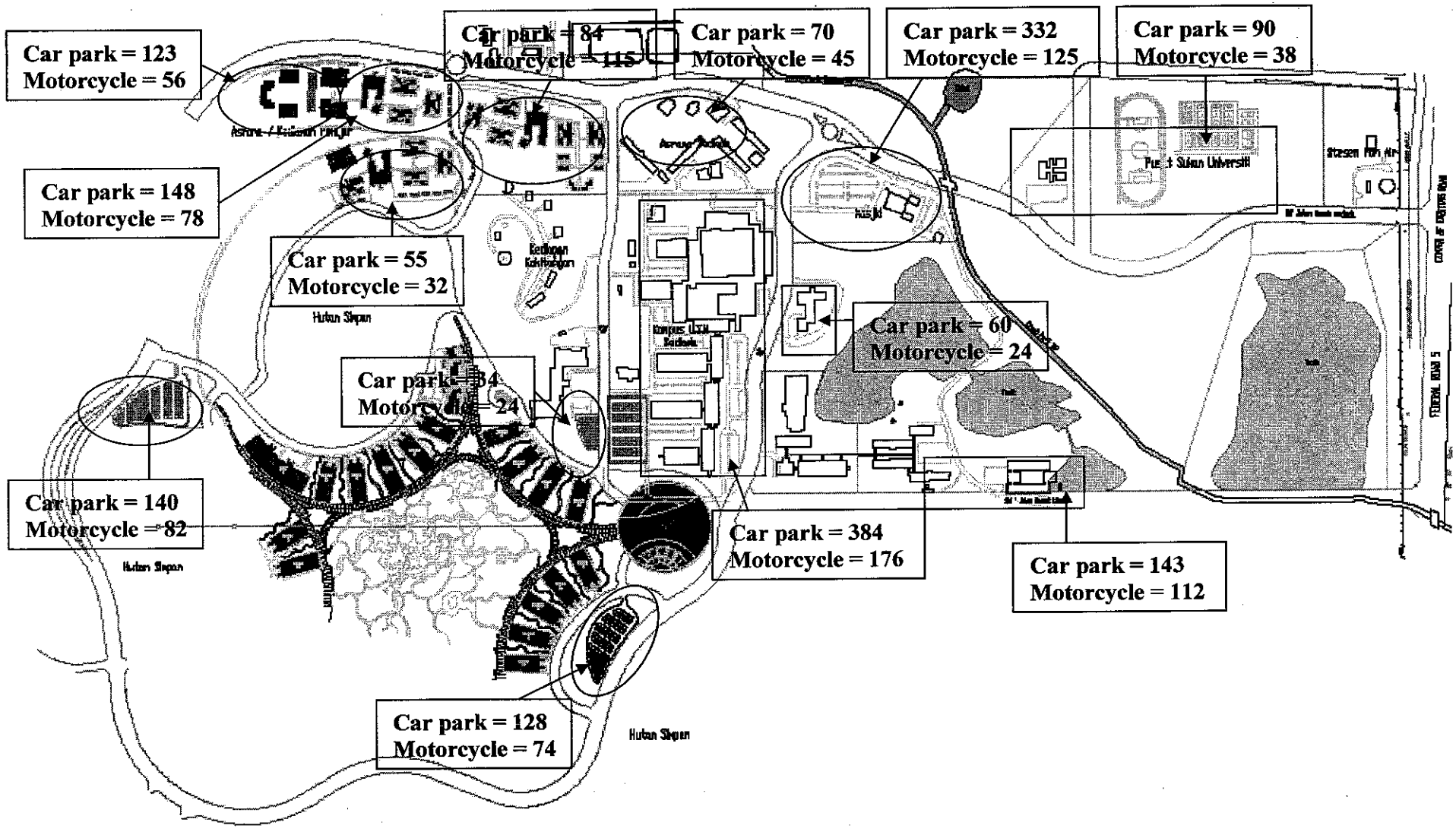

Figure 4.1: Location and Amount of Parking Spaces in UTP

4.3 Current Traffic Data

4.3.1 Current Traffic Routing

Figure 4.2 shows the current traffic routing at UTP. All the roads are of two ways in flow direction, and there are roads connecting the village hostels to the academic buildings. The traffic conditions in the campus do not indicate severe traffic congestions. However, congestions do occur at certain roads and intersections, depending on the time and situation of the occurrence.

The daily peak hours at the main entrance of UTP are the in the mornings (7.30 – 8.30am), lunch hours (12.30 – 2.30pm) and after work hours (4.30-5.30pm). The morning periods and evening periods mainly indicate the traffic flow of staffs and other personnel into and out of the campus. Besides, there is also a flow of traffic from the hostel parking lots to the old and new campus by students in the morning period. This shift of cars from the hostel area increases the traffic flow in the campus area. However, due to varying schedule of students, not all cars from the hostels will flow at the same time.

The road that leads to the new campus through village 3 has been observed for the first half of the semester and it has caused many traffic congestions. This was mainly due to the side parking done on both sides of the road, leaving a narrow lane for the two way traffic. Besides, traffic accidents are also prone to occur in this kind of situation. However, the issue of side parking has been greatly minimized due to the road sides being closed for parking for landscape upgrading, enabling a smoother flow of traffic.

Another observation worth noting is the sudden influx of traffic on Friday during 12.30pm to 2.00pm. This due to Friday prayers, and

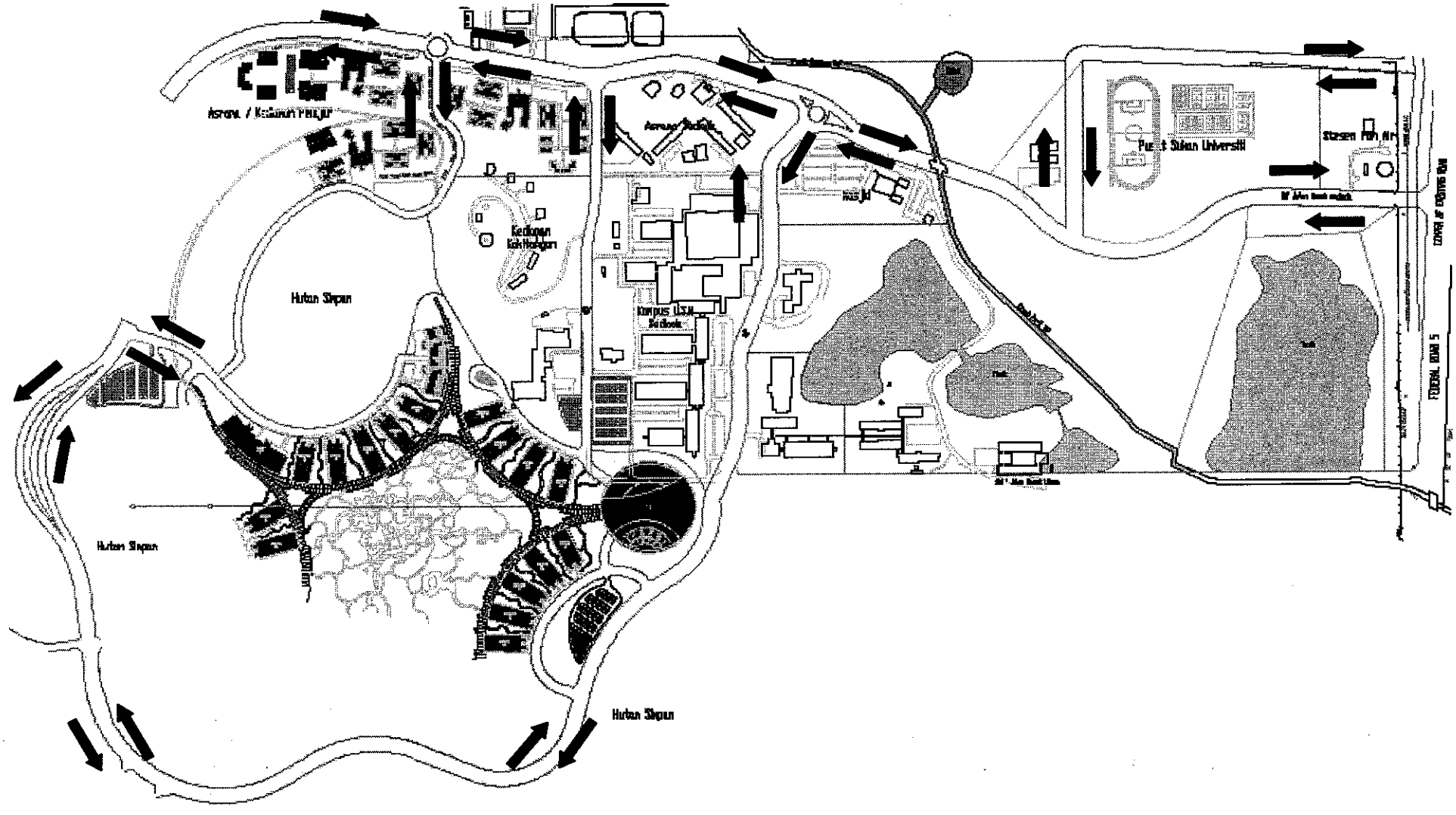

Figure 4.2: Current Traffic Routing in UTP

Muslims from the neighboring areas around the campus come to the UTP Mosque. Observations have shown that congestions do occur on the main campus road, however it lasts only during that duration. The congestions are rarely caused by illegal parking as there is sufficient parking bays at the UTP Main Hall.

4.3.2 Current Traffic Volume

Data from the volume studies conducted at the two roundabouts in UTP, Roundabout 1 and Roundabout 2, are placed in Appendix 5. The peak hourly flow of traffic at these two roundabouts is illustrated in Figure 4.3 and Figure 4.4.

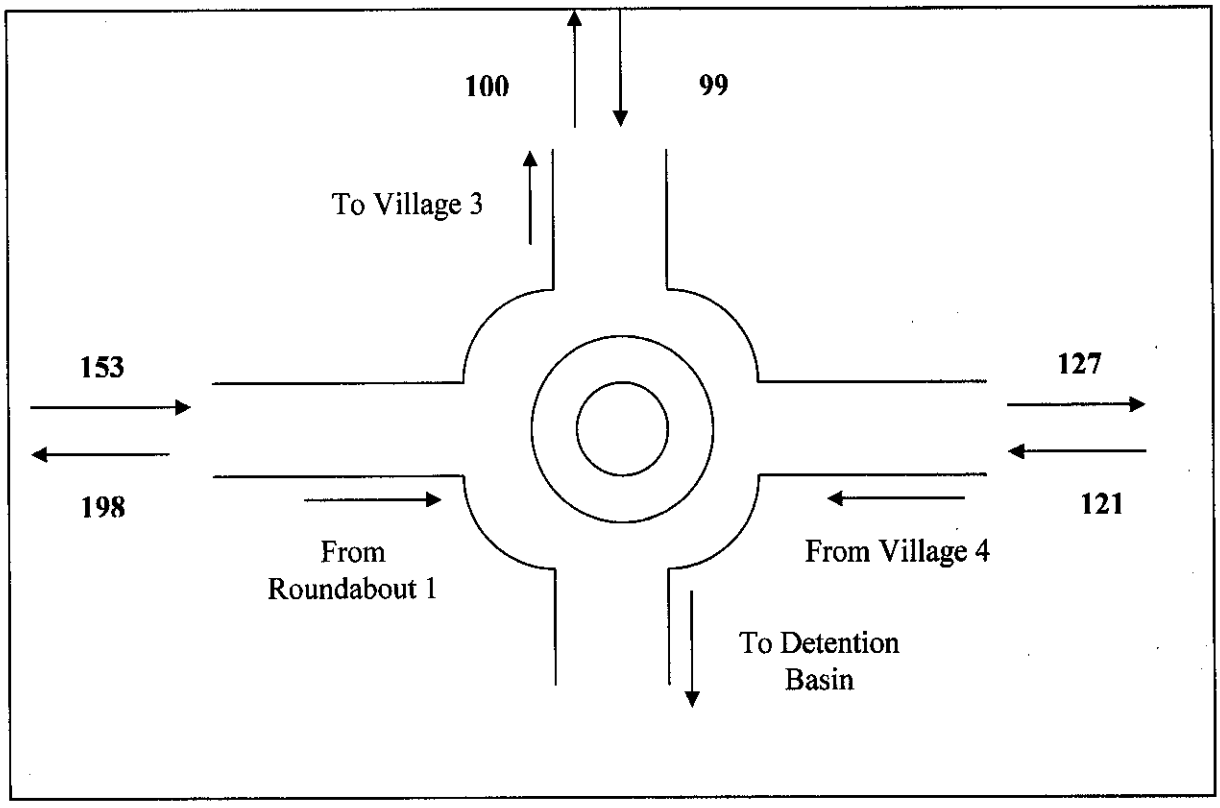

Figure 4.3: Current Peak Hourly Flow At Roundabout 1

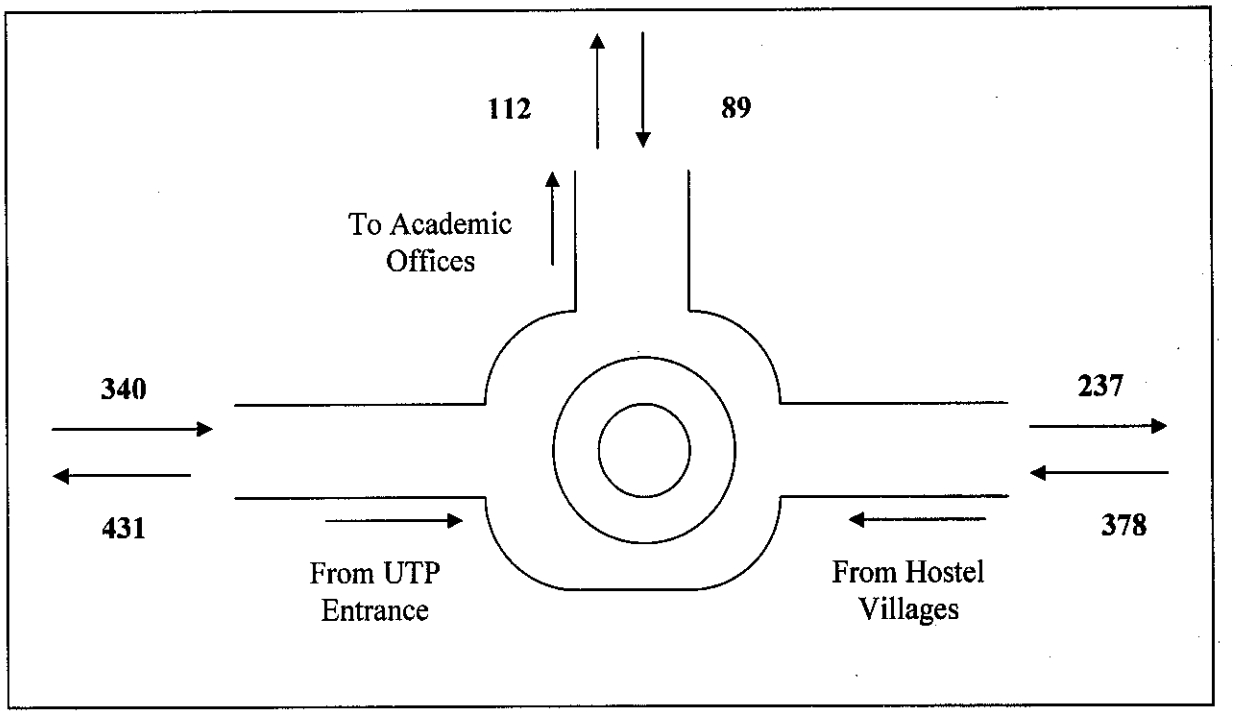

Figure 4.4: Current Peak Hourly Flow At Roundabout 2

4.3.3 Trip Generation Characteristics

The trip generation studies conducted was able to determine the possible connection between the three preset variables which were number of cars per household (each household has 12 students), number of trips per household, and average year of study. The full survey was tabulated and placed in Appendix 6.

A graph of household average year of study versus automobile ownership was plotted in Figure 4.5. From the graph, it can be deduced that, most cars are owned by fourth to fifth year students, with an average of five cars per household. The first and second year students on the other hand have less than 2 cars per household.

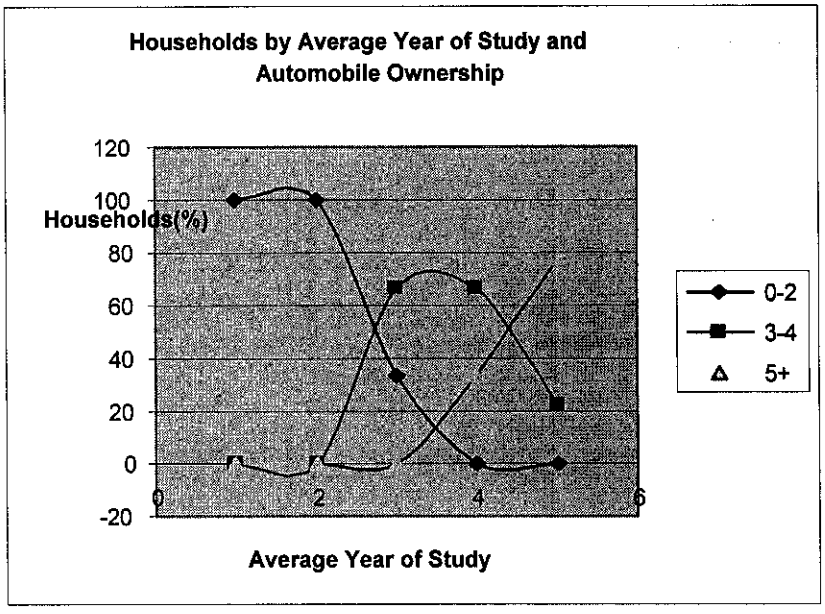

Figure 4.5: Relationship Between Average Year of Study and Automobile Ownership per household

Figure 4.6 indicates that the fourth to fifth year students generate more trips per household, partly because of the relatively high amount of cars ownership.

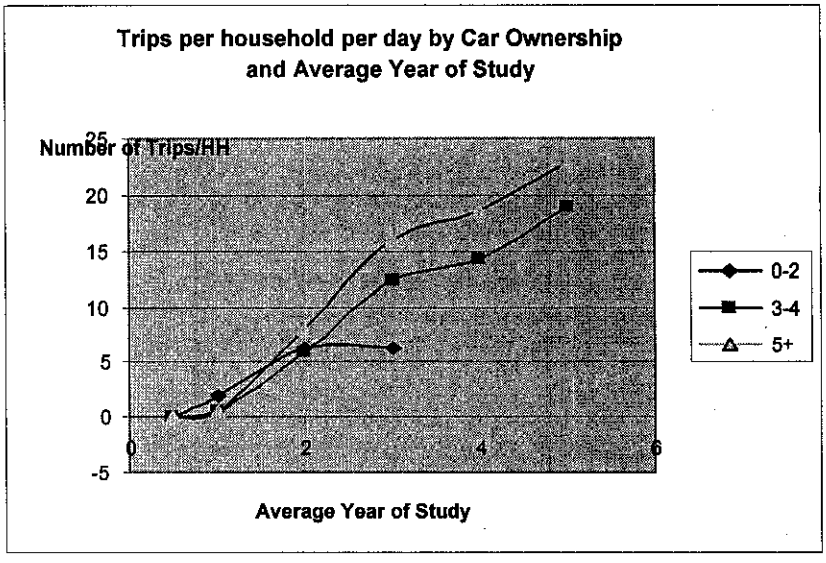

Figure 4.6: Relationship between number of trips per day and Average Year of Study per Household

4.3 Future Parking Scenario

4.4.1 Residential College

In order to determine the adequacy of the proposed parking spaces for hostels during the subsequent years of the university, a projected student population increase was tabulated. The university has imposed a limit to 6600 student population, averaging it to around 600 per intake. Furthermore, at any given time in the university, there would be approximately one batch of students undergoing industrial internship, and hence the total population living in the campus is approximated to 6000 students. The population tabulated below is based on a 10% increase per year until it reaches its maximum number of students of 6000.

Table 4.7: Projected Student Population in UTP

Year	Population
2004	4000
2005	4400
2006	4800
2007	5200
2008	5600
2009	6000
2010	6000

Based on Table 4.6 and Table 4.7 a projected amount of cars and motorcycles could be estimated. Consider the parking demand when the student population reaches 6000 students. Using the percentage from Table 4.6 (cars 18.4% and motorcycle 9.6%), an estimated 1104 parking spaces is required for cars, and 576 parking spaces for motorcycle.

Table 4.8: Projected Amount of Cars and Motorcycle

Year	Car	Motorcycle
2004	734	383
2005	810	422
2006	883	461
2007	957	500
2008	1030	538
2009	1104	576
2010	1104	576

The parking supply demand scenario during the year 2010 is shown in Table 4.8. It is therefore proposed to maintain the existing parking allocation, and new parking lots need to be constructed to cater for the demand of parking at hostels.

As part of the Traffic Management Control (refer to section 4.6.1), it is suggested that there be an imposed limit to number of cars owned by students in the campus to 1 000 units. This is a reduction of the actual required amount of parking space required in 2010. However, due to limitations of area in the campus surrounding, this measure to limit the cars to 1000 units is necessary. As for motorcycles, no imposed limits are proposed, and excess of parking space for motorcycles will be constructed.

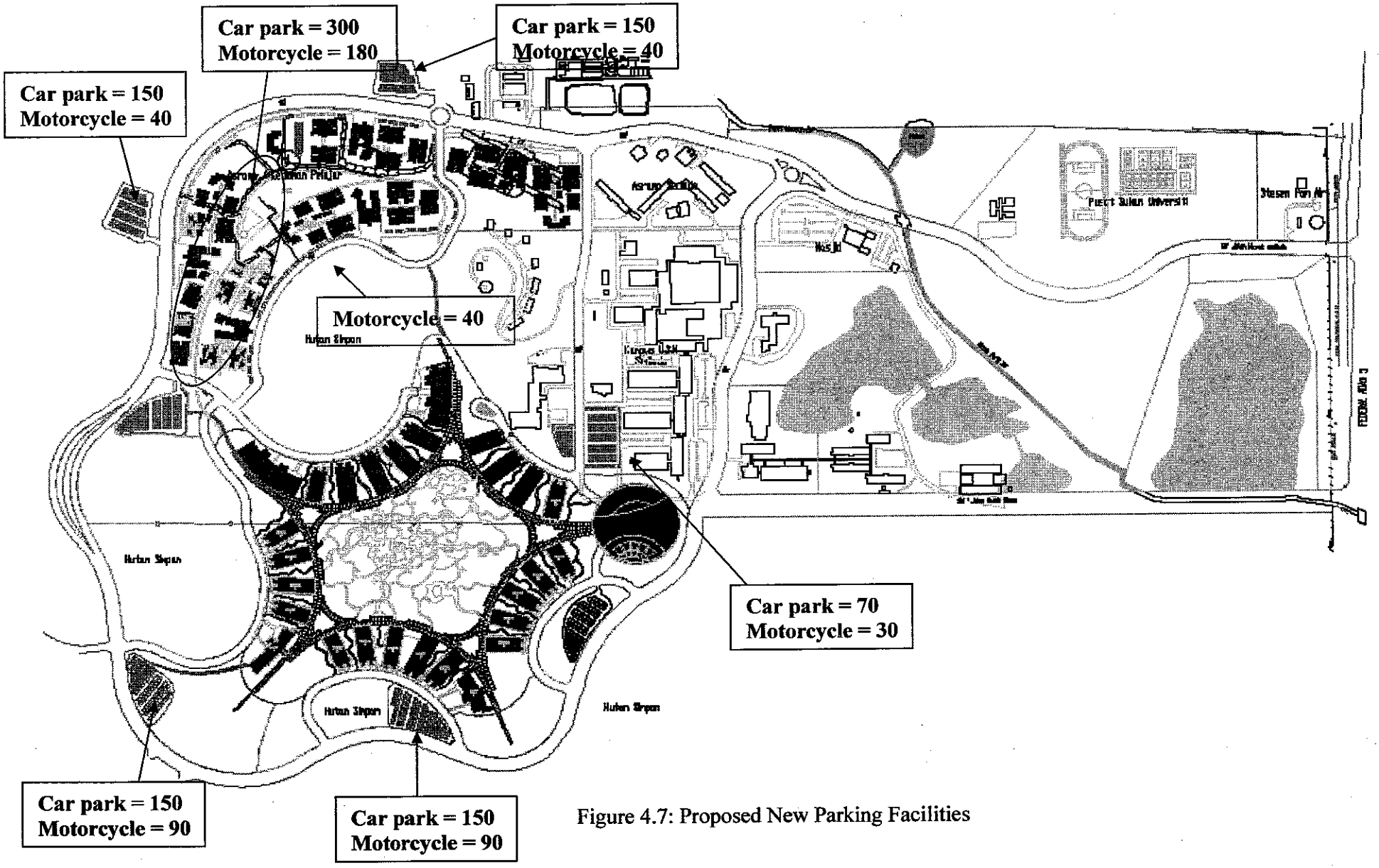

Figure 4.7: Proposed New Parking Facilities

Parking lots in village 1 will no longer be of used as students there will be relocated to the new villages. Hence, two new parking lots will be constructed adjacent to village 4 and between village 5 and the new village proposed for construction, as shown in Figure 4.7. Each parking lot will have a capacity of 150 parking bays for cars, and 40 parking bays for motorcycle. Besides, the road from roundabout 1 to pocket C will be converted into one way street (Refer to Section 4.6.2), hence the other part of the road will be used for parking allocation of 50 motorcycle bays.

Table 4.9: Table of Future Total Parking Facilities in UTP

Location	Car Parking Bays	Motorcycle Parking Bays
Combined Village 2-4	410	281
New Villages Being Constructed (3 x 100/village)	300	180
Two New Parking Lots	300	80
Curb changed for motorcycle parking bays		50
TOTAL	**1010**	**591**

4.4.2 Academic Offices

From Table 4.4, the only location with insufficient parking space is the Old Chemical Building. Students and staff park in this place for easier access to Pocket D and Blocks 19-22. The peak hour demand is 91 vehicle/h, while it only has 31 parking bays. Hence, new parking lot of about 70 car park bays and 30 motorcycle bays will be

constructed to cater for the current and future demand, as illustrated in Figure 4.7.

4.4.3 New Development of Academic Offices

In the proposed new development plan, another eight blocks of academic buildings (Block 5-12), and two new pockets (Pocket A and B) would be constructed in the future. To cater for the demand of these academic offices, another two new parking lots, each adjacent to pocket A and B will be constructed, as laid out in the UTP Master Plan. These parking lots will resemble the parking lot of Pocket C, having 150 car parking bays and 90 motorcycle parking bays each as illustrated in Figure 4.7.

An estimation of staff vehicles is done with the assumption that the university will employ approximately 700 staffs as compared to 470 at the current time. Bases on the ratio of student vehicles and motorcycles, there would be an estimated 447 cars and 253 motorcycles belonging to staffs in 2010.

The projection for staff vehicles shows that the parking facilities that are going to be constructed in the new academic building are adequate. An estimate of 90 staff cars will be located at each of the surrounding five parking lots around the new academic building. Furthermore, there would be more that enough parking lots for students to occupy at any given time of day. However, if in the future the demand increases, future expansion plans or new parking lots can be designed accordingly.

4.5 Future Traffic Scenario

The future traffic scenario differs from the current traffic flow due to several reasons. New roads are to be constructed to facilitate traffic flow, there is also a projected increase in amount of student and staff vehicles, and the

suggested implementation of new traffic management systems (refer to Section 4.6). The proposed new development plan has designed these new roads and is illustrated in Figure 4.8. The figure also illustrates the traffic routing, whether one way or two way roads for all the roads in UTP.

4.5.1 Trip Distribution

The trip distribution for future routing and flow of vehicles are based on the implemented new traffic management system (refer to Section 4.6) where a limited amount of student vehicles is imposed, and some roads are changes to one way streets. Based on this, several assumptions can be made to determine the future traffic flow at several locations.

i. The main entrance route will be mainly used by staffs, vendors and other visitors
ii. The secondary entrance will be predominantly used by students
iii. As a result, Roundabout 2 will experience less traffic from the academic offices, more traffic from hostels due to increase amount of vehicles
iv. Roundabout 1 will experience increase amount of traffic (the current volume ratio is used for the projection of traffic), road to pocket C from roundabout 2 is a one way street.

Figures 4.8 and 4.9 gives a rough estimate of the projected peak hour volume of vehicles. However, these projections are purely an estimation, based on the ratio of current routing, as there computer modeling was unavailable at the current moment.

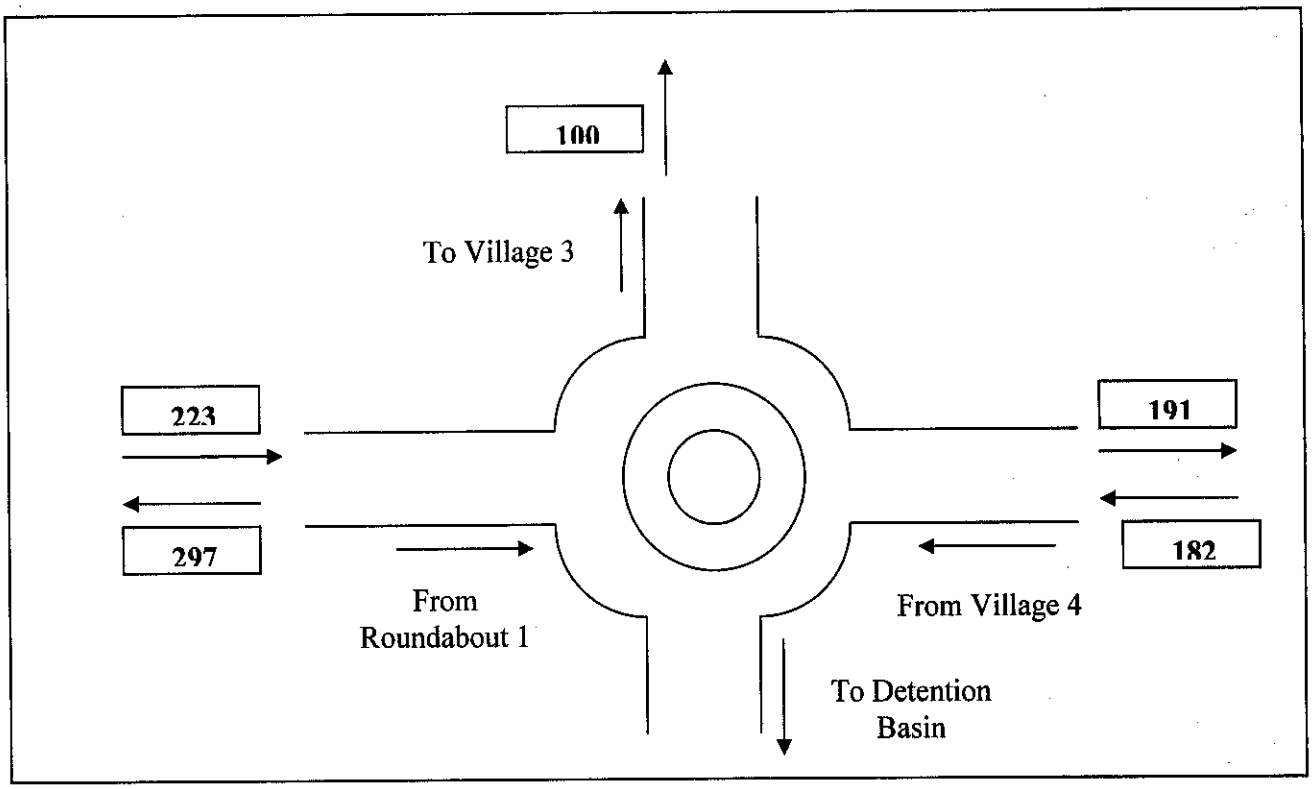

Figure 4.8: Future Routing at Roundabout 1

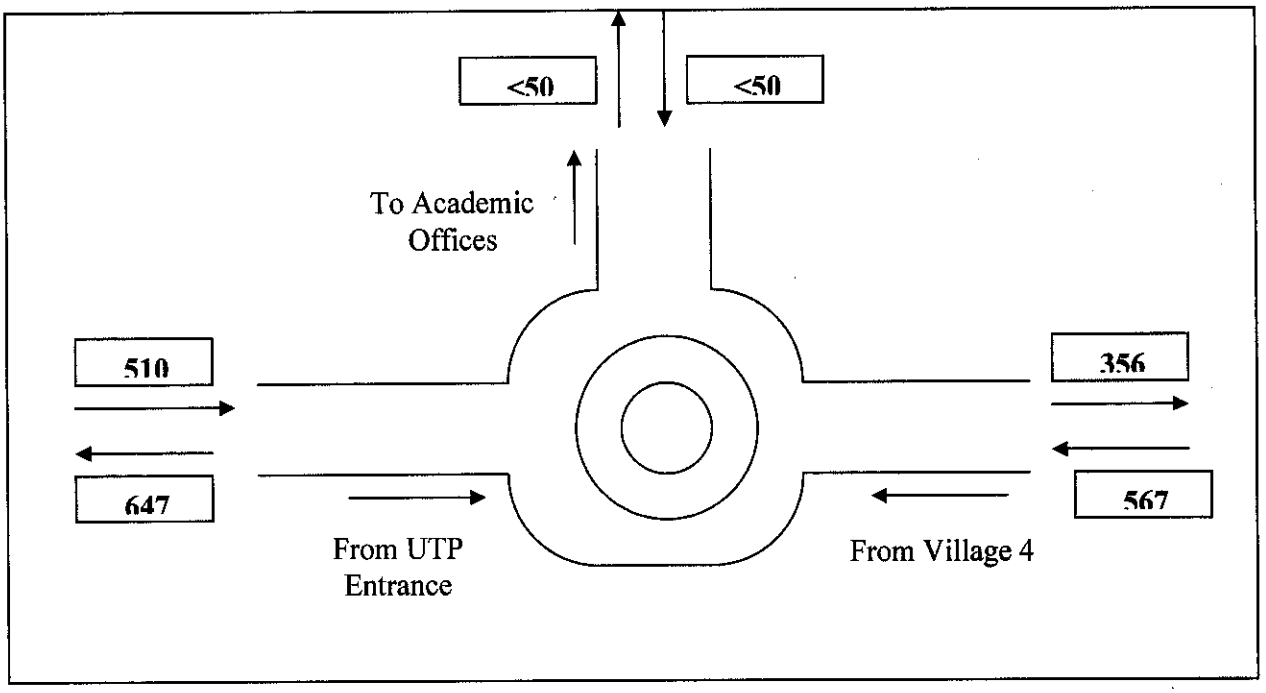

Figure 4.9: Future Routing at Roundabout 2

4.5.2 Future Traffic Circulation System

The future traffic circulation would see changes in the traffic distribution on the road networks. Firstly, the UTP entrance will be change to a new entrance, which directly leads to the Chancellor Hall. It is a safe assumption to stat that staffs will be predominantly using this route to the New Academic Blocks, as this is the nearest route to the blocks. The previous main entrance will be changed to become the secondary entrance. However, this route connects straight to the residential villages, which provides a better route for students to travel in and out of the university. By this, it can be deduced that the main entrance is predominantly used by staff and other vendors or visitors, while the secondary route will be dominated by student travels.

Several roads in the campus will be converted to one way streets. The road to Pocket C through village 3, which is narrowly built, will be more suitable to direct traffic in only one direction which is towards pocket C. The inner roads surrounding the new academic blocks will also be changed to one way streets to facilitate a better traffic flow. This road is assumed to have a high traffic volume as it is the most convenient access to the academic blocks. Besides, using these roads as two ways could cause traffic congestion and will reduce the usage of the outer ring road. Hence, these roads is changed to one way streets and traffic intending to move in the opposite direction will have to move towards the outer ring road at the accessible outlets in the future.

The whole campus will be connected to the university's outer ring road, which surrounds the whole areas of the campus. This road will form the major road arterial road network in the campus and connects to both the main and secondary entrances.

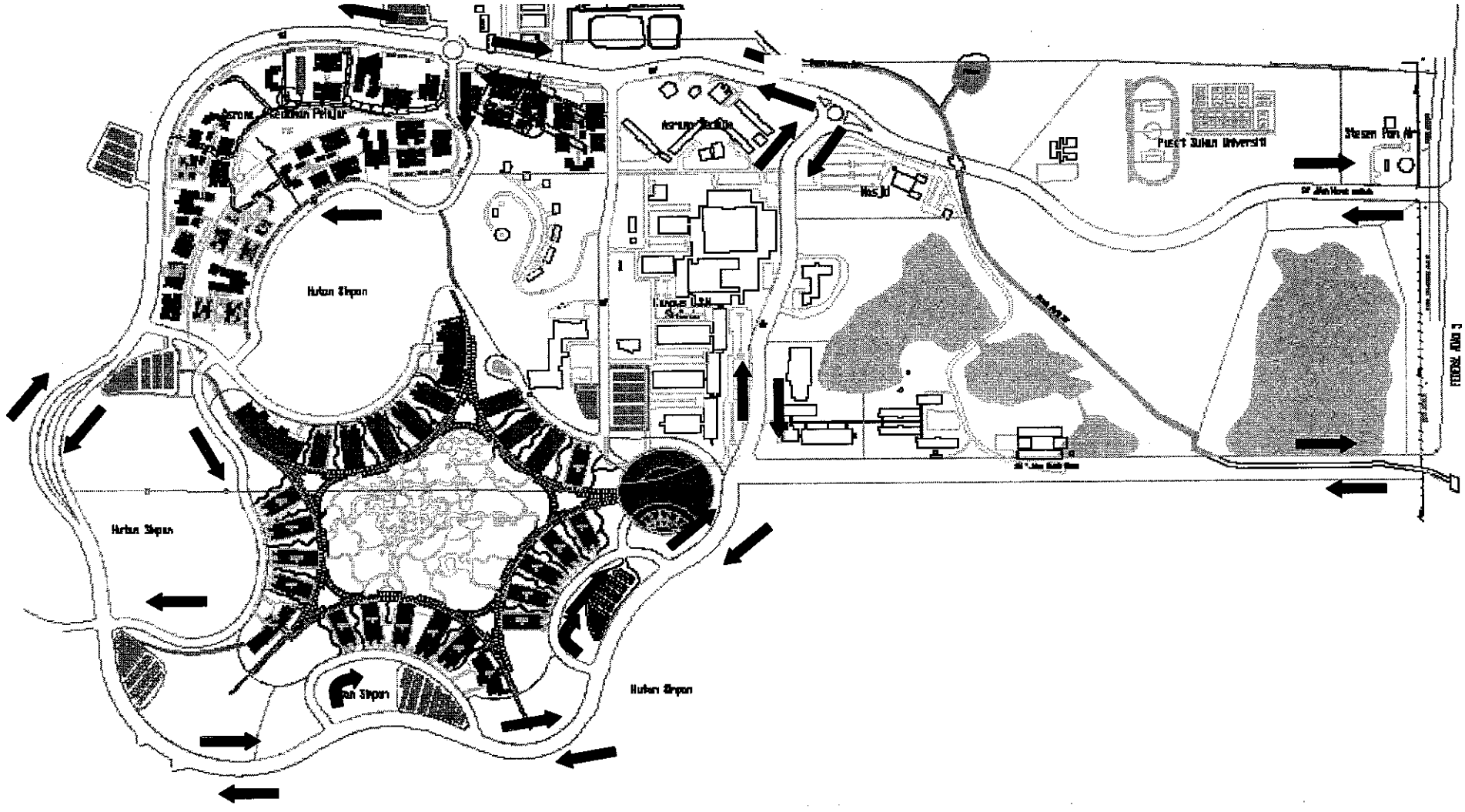

Figure 4.10: Future Traffic Routing

4.6 New Traffic Management System and Control

An integrated New Traffic Management System and Control covering the aspects of traffic, parking, and pedestrian comfort are suggested. This new system should be able to improve convenience, reduce transportation hazards, and improve safety.

4.6.1 Imposing Vehicle Limit and Relocation of Students

In order to cope with the increasing amount of student vehicle every year, a limit of 1000 cars would be capped for students. The reason is that there is limited space for parking near the village hostels, and a higher number of cars may amount to unwanted congestion in the university. The limit of 1000 vehicles brings a ratio of car per student to 1:6, when there are 6000 students in the university, although this ratio is well below the current ratio of 1: 5.45.

The selection for students that qualify to obtain car stickers from UTP will be based on the following criterion:

i. Seniority in the university is given preference.
ii. Active involvement in university activities, which includes clubs, societies and other university related functions
iii. First come basis of pre registration of vehicles, done together with pre residential college registration.

Relocation of students is a measure taken to place students more senior students in the new villages being constructed, as there are a lot of parking lots allocated. Based on the selection criterion of the student vehicles, it can be assumed that the more senior students will be having more cars, and should find comfort and convenience for their transportation needs in the new villages. The other villages will be used by more junior batches, and the student will also be distributed to fully utilize the parking space allocated for each village.

Village 2 and Village 3 will mainly be a living place for students who brought their motorcycles.

4.6.2 Diverting Roads to One Way Streets

Figure 4.10 shows the roads are being suggested to be converted to one way street. The road from the Roundabout 1 to Pocket C through Village 3 will be converted to one way street. The reason for this is that part of the road will be used for allocation of motorcycle parking bays. The road also used to be narrow tow way street, and hence it will become a more wide one way street. This in a way reduces traffic hazard and increases safety of motorist on this road.

The other roads which will be converted are the roads next to the new academic blocks. Currently, these roads are made of brick roads and only until full development is complete will these roads be tarred. The reason for converting these roads to one way streets is simply to ease traffic flow from one side of the academic block to the other. Those who wish to change direction can simply divert into the outer ring road of UTP which is a two road system.

4.6.3 Internal Bus / Shuttle Service

This measure is proposed in conjunction with the providing a convenient and easy accessible transportation system in the campus. In line with limiting the amount of student cars in the campus, this method would provide an alternative for students to maneuver themselves around the campus.

Two buses will be operating at various times, following a set bus route as shown in Figure 4.11. The list of bus stations are also shown in the table below. There are a total of 11 bus stops, and the operating hours, time of arrival at each bus stop are shown in Appendix 6.

Table 4.10: Location of the Proposed Bus Stops

Bus Stop No.	Location
1	New Proposed Village
2	Village5
3	Village 4
4	Village 3
5	Pocket C
6	Pocket B
7	Pocket A
8	Chancellor Hall
9	Administration Building
10	BCB Bank
11	Village 2

The bus route will start from Bus Stop 1, making its route to the new academic blocks, chancellor hall, old administration building and back to the hostels. The bus will go to each bus stop is in the following order; 1,2,3,4,5,6,7,8,9,10,11,2,1. There will be five bus trips in an hour to provide adequate service for the students. The time taken for the whole route is 15 minutes approximately.

The bus/shuttle service system is able to provide the convenience to students to move from one place to another fast and at ease. With the construction of the new academic blocks and pockets, the distance from the hostel to these places are relatively far. Furthermore, with the implementation of the vehicle limit, this seems as a reasonable solution for the traveling needs of these students.

4.6.4 Shaded Pedestrian Walkways

Shaded pedestrian walkways will be installed at three locations as shown in Figure 4.11. The first walk way connects the village with

Pocket D, Pocket C to the Pocket C car park, and the other is from Pocket B to Pocket B Car Park.

The purpose of these shaded walkways is to ensure comfort for those who wish to walk to the new academic buildings. There has been much complaints from the students about walking under the Tronoh weather conditions, and this feature should add to the convenience of the students.

4.6.5 Traffic Enforcements

Besides implementation of the New Traffic Management System its enforcement is also important to ensure the integrity of the system. The enforcement in the university is currently done by the security officers attached with the security department. In retrospect, they will continue to issue summonses to motorist who break the traffic regulations, perform illegal parking, and other offences that violate the New Traffic Management System.

Besides, the Residential College Unit will have to select the 1000 units of cars that can be brought into the university, based on the selection criterion mentioned in Section 4.6.1. Then students will be placed accordingly to the various hostels.

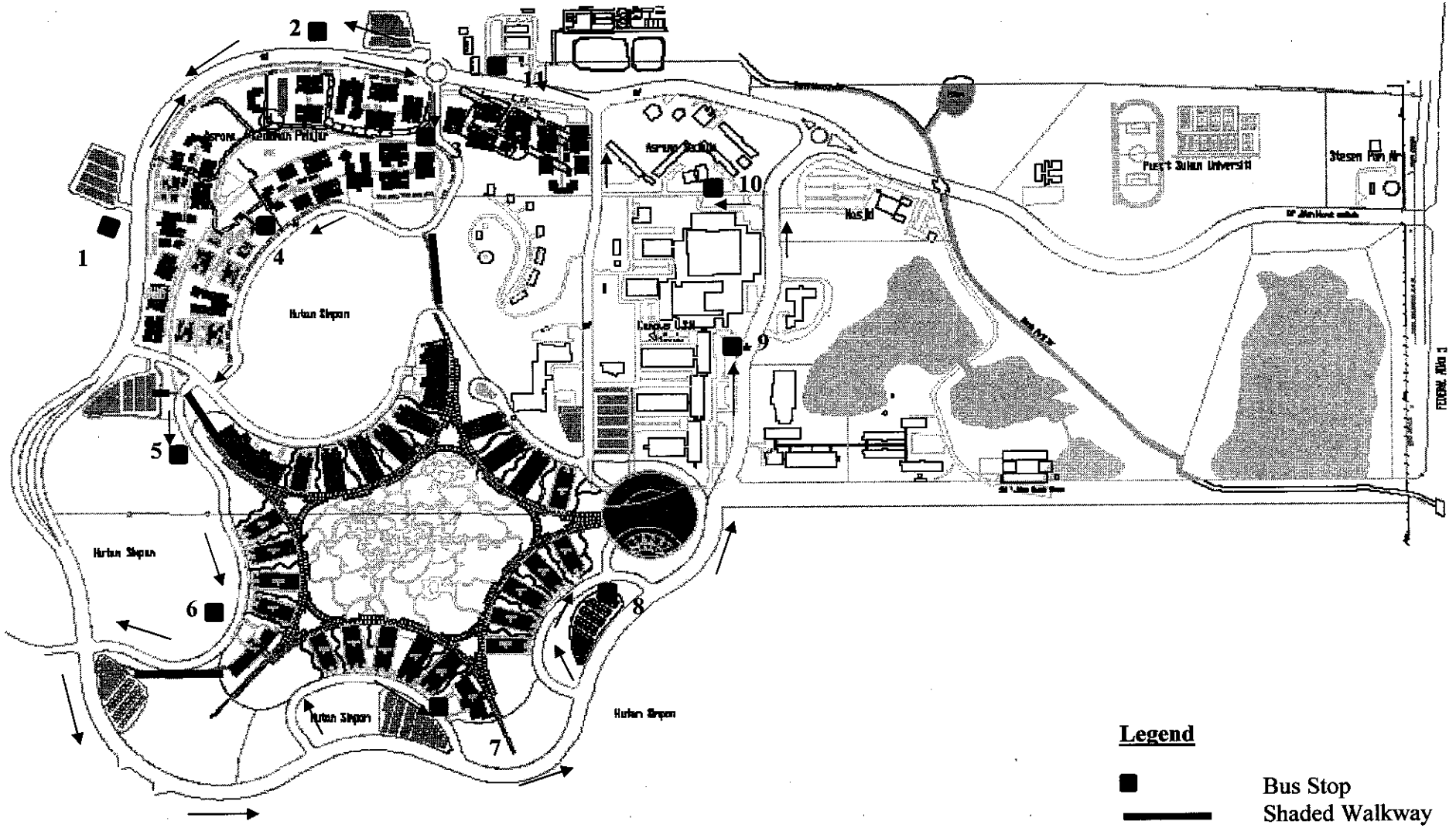

Table 4.11: Proposed New Traffic Management System

CHAPTER 5

RECOMMENDATION

The objectives of this project were able to be achieved at the end of this project. The parking problem and a new traffic management system have been suggested to be implemented in UTP for comfort and convenience of staff and students. However, there is certainly room for improvement in the way the project way handled, and also due to some unforeseen limitations.

This project could have been further improved by having analyzed the data through a computer traffic modeling software. Computer Modelling provides better data sorting and analysis compared to manual method. Paramics Modeling Software is one of the Traffic Modeling Softwares that can be used to analyze traffic and parking data. This programme is able to analyze traffic demand, perform traffic assignments, build the transportation network, and even perform other analysis which would be of burden to be performed manually.

The other recommendation suggested is to gather more detailed data using automatic counts, compared to manual count obtained in this project. By using automatic counts for traffic volume, data for 24 hours for a longer duration can be obtained, hence making the results seem more credible. Currently, the traffic data obtained for a period of several hours of several days due to limitations of manual counts. Hence, using automatic counts, more data can be recovered, and also more locations can be placed with such counters to fully analyze all traffic volume.

Another recommendation suggested is to have a thorough analysis on the many traffic management systems that can be implemented in UTP. The bus/shuttle service was recommended in this project due to its suitability based on acquired data. However, there might be a better possibility or finding a better solution through computer modeling, where the variables and parameters can be analyzed more accurately. Besides there may be other approaches to provide better traffic management in UTP, and probably a project on the comparison of the various alternatives of traffic management measures could be done to provide the best solution to UTP.

As far as this project is concerned, it is very much hoped that the UTP management considers the suggested solutions in this project. There are major issues like inadequate parking facilities at hostels, and it is best if UTP addresses this timely issue quickly. With the new hostels currently being constructed, these parking facilities should be provided to avoid inadequacies.

CHAPTER 6

CONCLUSION

In conclusion, all four objectives of this project were met. This projects first objective which was aimed at studying and analyzing the current traffic pattern in the campus was conducted. The traffic pattern in UTP is moderate and not sufficient to cause traffic congestion, unless there is a sudden incident that blocks the road. Most of the trips in UTP are generated by the students as all of them are located in campus grounds. The trip generation survey also revealed that students of seniority tend have more student to car ratio, and also they generate more trips daily then the others.

Objective 2 of designing a better traffic circulation system in the campus was focused on changing some roads to one-way streets. These streets were change mainly to facilitate a smoother flow of traffic, and also the road to pocket C through village 3 will be partly used for parking improvements. The university has already had a pre laid out road network to cater for the full development of the campus, and the traffic circulation for this road network seems suitable to cater for future need.

Most prominent suggestion of this project came from the third objective which was to optimize parking space within the campus. Two new parking lots were suggested to cater for the demand of the students. Other parking lots were also suggested at the new academic blocks to cater for the two new pockets those are yet to be constructed. Furthermore, the parking availability is very much related to the traffic management measure of imposing a car limit of 1000 for students, and adequate parking lots for the hostels were designed.

In the final objective of devising a new traffic management scheme, various measure sof different purpose and scale were suggested. Proposal to implement the bus/shuttle service in UTP was the main measure to provide convenience and comfortable accessibility to other parts of the campus. Besides imposing the vehicle limit, traffic enforcement is very much enforced to ensure this new system is well in place and traffic offences are kept to a minimum.

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CHAPTER 7

APPENDIX

Table of Appendix

Appendix 1: Gantt Chart Work Schedule

Appendix 2: Overall Campus Layout Plan

Appendix 3: Full Development Campus Layout Plan

Appendix 4: Parking Accumulation Data

Appendix 5: Volume Counts

Appendix 6: Trip Generation Data

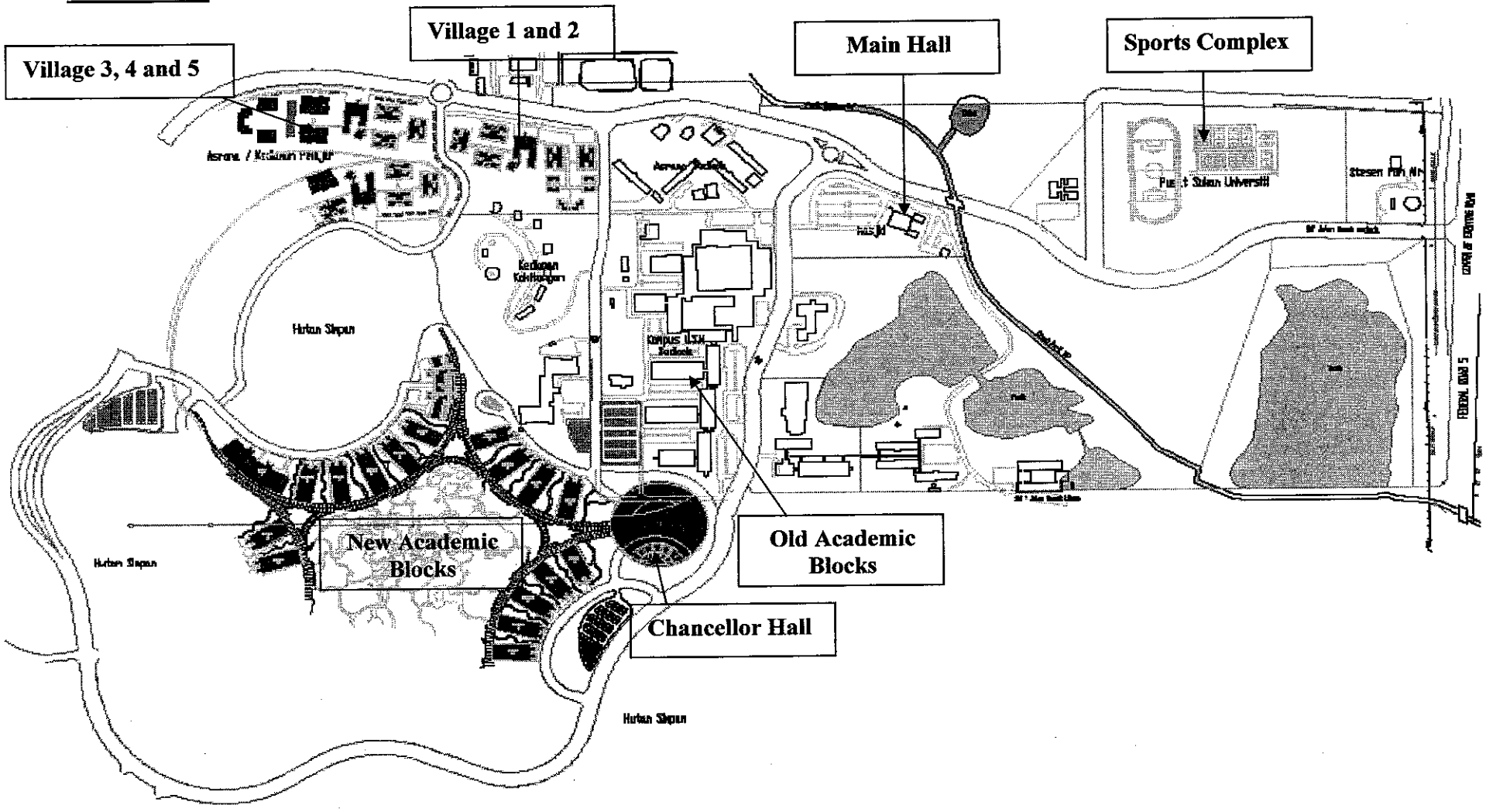
Appendix 7: Time Arrival Schedule at Bus Stops

APPENDIX 1

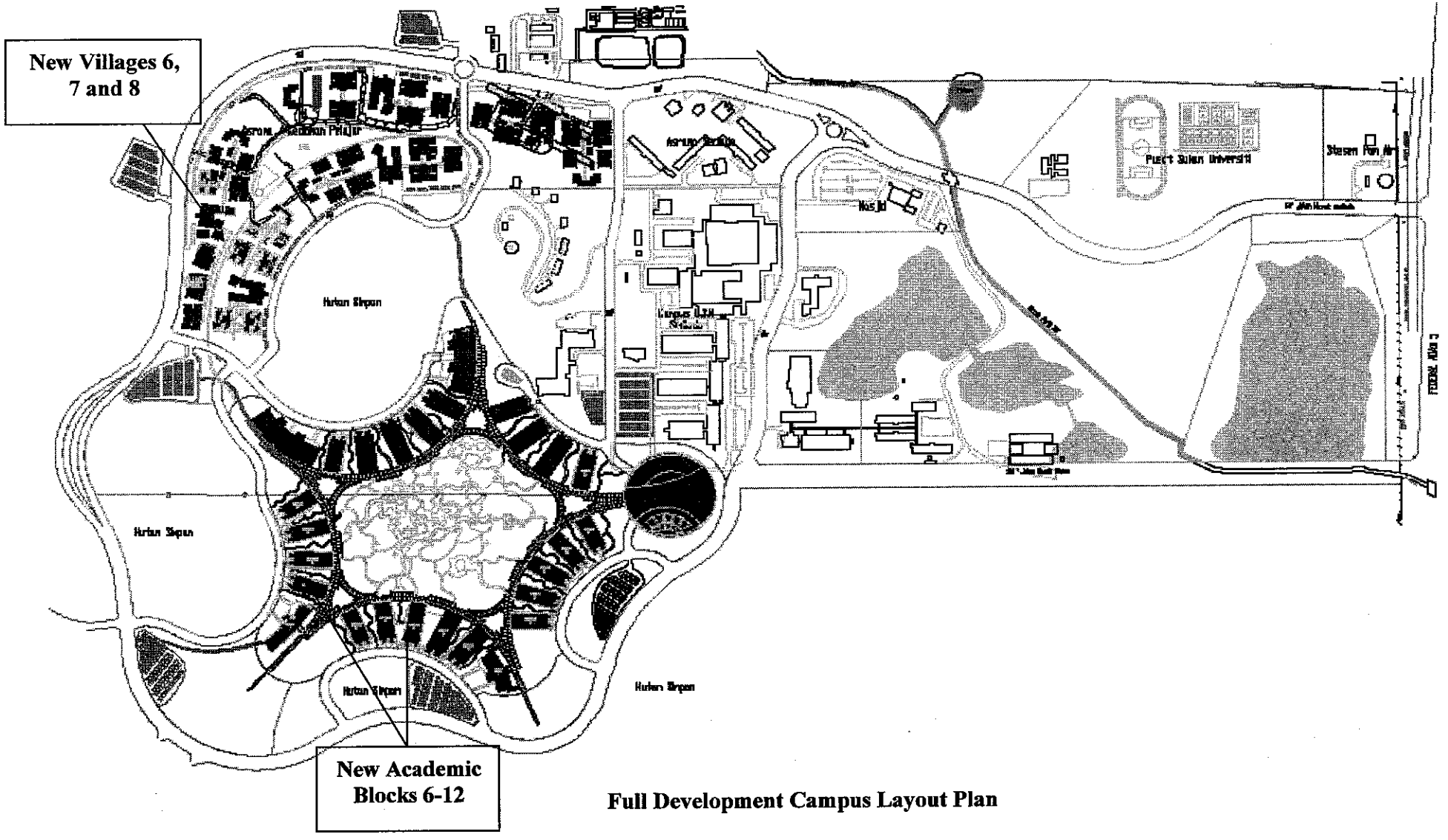
Description / Actvities	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEPT	OCT	NOV	DEC
Selection of Project Topic											
Preliminary Research Work											
Project Work – Literature Review											
Submission of Interim Report											
Conducting Traffic Studies and Analysis											
Parking Studies and Analysis											
Creating a New Traffic Management System											
Submission of Dissertation											

Gantt Chart of Work Schedule

APPENDIX 2


Village 1 and 2
Village 3, 4 and 5
Main Hall
Sports Complex
New Academic Blocks
Old Academic Blocks
Chancellor Hall

APPENDIX 3



Full Development Campus Layout Plan

APPENDIX 4 – PARKING ACCUMULATION DATA

Parking Accumulation at Admin Block Date of Survey:26/08/2004

Time	No of Cars Parked Legally	No of Cars Parked Illegally	No of Motorcycles Parked Legally	No of Motorcycles Parked Illegally
8	45	0	12	0
9	48	1	12	0
10	47	1	12	0
11	46	0	14	0
12	39	0	13	0
13	13	0	7	0
`14	44	0	13	0
15	47	1	12	0
16	42	0	12	0
17	5	0	12	0

Parking Accumulation at Library Date of Survey:26/08/2004

Time	No of Cars Parked Legally	No of Cars Parked Illegally	No of Motorcycles Parked Legally	No of Motorcycles Parked Illegally
8	18	0	7	0
9	46	0	12	0
10	62	0	34	0
11	84	0	22	0
12	56	0	45	0
13	18	0	18	0
14	31	0	26	0
15	36	0	23	0
16	21	0	16	0
17	11	0	9	0

Parking Accumulation At Pocket C Date of Survey:26/08/2004

Time	No of Cars Parked Legally	No of Cars Parked Illegally	No of Motorcycles Parked Legally	No of Motorcycles Parked Illegally
8	5	0	0	0
9	12	0	0	0
10	17	0	4	0
11	21	0	3	0
12	13	0	6	0
13	3	0	3	0
14	7	0	6	0
15	9	0	15	0
16	19	0	4	0
17	3	0	5	0

Parking Accumulation At Old Chemical Block

Date of Survey:26/08/2004

Time	No of Cars Parked Legally	No of Cars Parked Illegally	No of Motorcycles Parked Legally	No of Motorcycles Parked Illegally
8	18	2	12	4
9	34	52	24	8
10	34	57	24	15
11	31	46	24	17
12	30	42	24	13
13	13	20	14	6
14	29	36	20	12
15	32	34	22	15
16	28	22	24	25
17	21	18	9	12

Hostels

Parking Accumulation At Village 1

Date of Survey:26/08/2004

Time	No of Cars Parked Legally	No of Cars Parked Illegally	No of Motorcycles Parked Legally	No of Motorcycles Parked Illegally
8	34	0	24	0
9	31	0	23	0
10	28	0	15	0
11	24	0	14	0
12	26	0	17	0
13	15	0	18	0
14	18	0	13	0
15	25	0	21	0
16	19	0	21	0
17	23	0	16	0
18	21	0	22	0
19	16	0	22	0
20	24	0	23	0
21	27	0	23	0
22	29	0	19	0
23	32	0	22	0
24	34	0	22	0

Parking Accumulation At Village 2 Date of Survey:26/08/2004

Time	No of Cars Parked Legally	No of Cars Parked Illegally	No of Motorcycles Parked Legally	No of Motorcycles Parked Illegally
8	84	17	78	0
9	76	15	73	0
10	74	12	67	0
11	71	7	56	0
12	76	7	34	0
13	63	5	38	0
14	60	4	58	0
15	58	7	42	0
16	62	8	53	0
17	73	8	67	0
18	69	10	69	0
19	74	8	56	0
20	75	6	37	0
21	80	14	41	0
22	84	13	59	0
23	84	14	69	0
24	84	20	75	0

Parking Accumulation At Village 3 Date of Survey:26/08/2004

Time	No of Cars Parked Legally	No of Cars Parked Illegally	No of Motorcycles Parked Legally	No of Motorcycles Parked Illegally
8	48	126	32	27
9	42	98	32	24
10	46	58	26	17
11	40	51	23	14
12	36	42	26	18
13	35	49	24	17
14	41	52	15	13
15	43	67	19	13
16	50	82	28	21
17	52	69	28	23
18	47	88	25	17
19	45	92	26	19
20	39	86	32	20
21	53	96	32	25
22	55	119	32	23
23	55	125	32	27
24	55	135	32	28

Parking Accumulation At Village 4 Date of Survey:26/08/2004

Time	No of Cars Parked Legally	No of Cars Parked Illegally	No of Motorcycles Parked Legally	No of Motorcycles Parked Illegally
8	138	58	78	6
9	125	49	65	5
10	116	46	61	7
11	90	29	49	9
12	76	22	41	5
13	70	13	38	0
14	88	17	49	5
15	81	16	57	6
16	99	19	39	0
17	110	26	51	4
18	106	21	59	5
19	126	16	70	6
20	118	12	62	4
21	136	26	66	6
22	147	46	78	6
23	148	48	78	6
24	148	60	78	6

Parking Accumulation At Village 5 Date of Survey:26/08/2004

Time	No of Cars Parked Legally	No of Cars Parked Illegally	No of Motorcycles Parked Legally	No of Motorcycles Parked Illegally
8	114	15	56	12
9	106	12	43	10
10	93	11	46	15
11	82	8	39	15
12	81	5	31	14
13	75	5	26	8
14	83	5	43	12
15	86	5	47	9
16	81	6	41	15
17	91	5	39	11
18	102	7	56	10
19	96	5	46	8
20	108	5	41	7
21	113	5	35	11
22	112	7	39	12
23	123	15	51	12
24	123	21	56	14

APPENDIX 5 – VOLUME COUNTS

Location: Road from Roundabout 1 to Pocket C (Date: 3/8/2004)

Time	Volume of Cars to Pocket C	Volume of Cars to Roundabout 1	Volume of Motorcycle to Pocket C	Volume of Motorcycle to Roundabout 1	PCU	
					To Pocket C	To Roundabout 1
8	54	22	18	6	**60**	**24**
9	53	31	10	7	**56**	**33**
10	68	34	11	7	**72**	**36**
11	93	74	14	5	**98**	**76**
12	95	95	17	11	**101**	**99**
13	46	76	9	10	**49**	**79**
14	76	51	7	7	**78**	**53**
15	38	62	14	9	**43**	**65**
16	33	57	6	13	**35**	**61**
17	43	72	12	14	**47**	**77**

Location: Road from Roundabout 1 to Pocket C (Date: 11/8/2004)

Time	Volume of Cars to Pocket C	Volume of Cars to Roundabout 1	Volume of Motorcycle to Pocket C	Volume of Motorcycle to Roundabout 1	PCU	
					To Pocket C	To Roundabout 1
8	45	29	10	5	**48**	**31**
9	55	23	7	6	**57**	**25**
10	64	46	5	3	**66**	**47**
11	56	49	2	8	**57**	**52**
12	84	89	9	8	**87**	**92**
13	76	84	15	13	**81**	**88**
14	85	75	13	2	**89**	**76**
15	54	61	5	16	**56**	**66**
16	36	54	13	13	**40**	**58**
17	37	69	6	3	**39**	**70**

Location : Road From Roundabout 1 to Village 4 (Date: 3/8/2004)

Time	Volume of Cars to Village 4	Volume of Cars to Roundabout 1	Volume of Motorcycle to Village 4	Volume of Motorcycle to Roundabout 1	PCU	
					To Village 4	To Roundabout 1
8	23	16	7	7	**25**	**18**
9	46	31	15	6	**51**	**33**
10	41	33	12	8	**45**	**36**
11	68	56	4	13	**69**	**60**
12	95	68	9	15	**98**	**73**
13	123	118	12	9	**127**	**121**
14	88	99	9	11	**91**	**103**
15	49	65	8	11	**52**	**69**
16	58	64	6	13	**60**	**68**
17	37	41	13	7	**41**	**43**

Location : Road From Roundabout 1 to Village 4 (Date: 11/8/2004)

Time	Volume of Cars to Village 4	Volume of Cars to Roundabout 1	Volume of Motorcycle to Village 4	Volume of Motorcycle to Roundabout 1	PCU	
					To Village 4	To Roundabout 1
8	35	33	2	3	**36**	**34**
9	25	36	6	3	**27**	**37**
10	45	37	8	8	**48**	**40**
11	43	24	4	2	**44**	**25**
12	71	61	13	6	**75**	**63**
13	95	83	4	4	**96**	**84**
14	94	84	9	10	**97**	**87**
15	51	77	14	6	**56**	**79**
16	26	69	6	6	**28**	**71**
17	38	56	5	9	**40**	**59**

Location: Road from Village 2 to Roundabout 1 (Date: 3/8/2004)

Time	Volume of Cars to Roundabout 1	Volume of Cars to Village 2	Volume of Motorcycle to Roundabout 1	Volume of Motorcycle to Village 2	PCU	
					To Roundabout 1	To Village 2
8	66	32	14	13	**71**	**36**
9	84	49	37	18	**96**	**55**
10	102	68	26	26	**111**	**77**
11	136	99	33	39	**147**	**112**
12	106	135	18	26	**112**	**144**
13	94	189	33	28	**105**	**198**
14	143	139	31	37	**153**	**151**
15	67	107	38	16	**80**	**112**
16	71	64	23	36	**79**	**76**
17	59	86	29	29	**69**	**96**

Location: Road from Village 2 to Roundabout 1 (Date: 11/8/2004)

Time	Volume of Cars to Roundabout 1	Volume of Cars to Village 2	Volume of Motorcycle to Roundabout 1	Volume of Motorcycle to Village 2	PCU	
					To Roundabout 1	To Village 2
8	61	36	12	5	**65**	**38**
9	62	49	10	11	**65**	**53**
10	98	53	12	10	**102**	**56**
11	99	111	5	6	**101**	**113**
12	126	129	18	13	**132**	**133**
13	91	142	17	16	**97**	**147**
14	135	98	24	13	**143**	**102**
15	75	76	13	19	**79**	**82**
16	62	92	11	13	**66**	**96**
17	75	91	14	17	**80**	**97**

Location: Road from UTP Entrance to Roundabout 2 (Date: 20/9/2004)

Time	Volume of Cars to Roundabout 2	Volume of Cars to Entrance	Volume of Motorcycle to Roundabout 2	Volume of Motorcycle to Entrance	PCU	
					To Roundabout	To Entrance
8	179	53	56	19	198	59
9						
10						
11	143	221	76	38	168	234
12	167	298	51	31	184	308
13	236	415	67	49	258	431
14						
15						
16						
17						

Location: Road from UTP Entrance to Roundabout 2 (Date: 22/9/2004)

Time	Volume of Cars to Roundabout 2	Volume of Cars to Entrance	Volume of Motorcycle to Roundabout 2	Volume of Motorcycle to Entrance	PCU	
					To Roundabout	From Entrance
8						
9						
10						
11	134	161	65	44	156	176
12	153	253	35	48	165	269
13	321	359	57	56	340	378
14	286	276	37	34	298	287
15						
16						
17						

Location: Road from Roundabout 2 to Academic Offices (Date: 20/9/2004)

Time	Volume of Cars to Academic Offices	Volume of Cars to Roundabout 2	Volume of Motorcycle to Academic Offices	Volume of Motorcycle to Roundabout 2	PCU	
					To Academic Offices	To Roundabout 2
8	98	23	43	12	112	27
9						
10						
11	58	56	34	21	69	63
12	76	74	37	18	88	80
13	46	81	51	24	63	89
14						
15						
16						
17						

Location: Road from Roundabout 2 to Academic Offices (Date: 22/9/2004)

Time	Volume of Cars to Academic Offices	Volume of Cars to Roundabout 2	Volume of Motorcycle to Academic Offices	Volume of Motorcycle to Roundabout 2	PCU	
					To Academic Offices	To Roundabout 2
8						
9						
10						
11	64	49	34	18	75	55
12	72	55	35	22	84	62
13	58	75	57	35	77	87
14	47	71	37	31	59	81
15						
16						
17						

Location: Road from Roundabout 2 to Village 2 (Date: 20/9/2003)

Time	Volume of Cars to Village 2	Volume of Cars to Roundabout 2	Volume of Motorcycle to Village 2	Volume of Motorcycle to Roundabout 2	PCU	
					To Village 2	To Roundabout 2
8	82	35	15	17	87	41
9						
10						
11	89	168	44	19	104	174
12	98	231	16	16	103	236
13	205	336	19	26	211	345
14						
15						
16						
17						

Location: Road from Roundabout 2 to Village 2 (Date: 22/9/2003)

Time	Volume of Cars to Village 2	Volume of Cars to Roundabout 2	Volume of Motorcycle to Village 2	Volume of Motorcycle to Roundabout 2	PCU	
					To Village 2	To Roundabout 2
8						
9						
10						
11	75	161	65	44	97	176
12	101	253	35	48	113	269
13	121	359	45	56	136	378
14	223	276	42	34	237	287
15						
16						
17						

APPENDIX 6

Household Number	Trips Produced per Household	Average Year of Study	Cars Per Household	Reference
1	20	5	5	5(12)
2	22	5	6	5(12)
3	18	4.9	6	5(10), 4.5(2)
4	16	2.5	4	3(6), 3(4)
5	14	3.2	3	3(8), 3.5(4)
6	9	2	2	2(12)
7	6	2.5	1	2.5(12)
8	10	2.8	3	2.5(6), 3(6)
9	8	2.5	2	2(4), 2.5(4), 3(4)
10	15	3.6	4	3.5(10), 4(2)
11	24	4.8	6	5(8), 4.5(4)
12	4	1.5	1	1.5(12)
13	4	1.8	2	1.5(6), 2(6)
14	14	3.1	3	3(10), 3.5(2)
15	15	3	3	2(4), 3.5(8)
16	16	4.7	3	4.5(8), 5(4)
17	18	4.9	5	4.5(3), 5(9)
18	5	2.8	1	2.5(4), 3(8),
19	19	3.6	6	3.5(10), 4(2)
20	4	0.75	1	0.5(6), 1(6)
21	8	1.8	2	1.5(5), 2(7)
22	12	2.3	3	2(4), 2.5(8)
23	18	4.7	5	4.5(7), 5(5)
24	14	3.9	3	3.5(2), 4(10)
25	9	2.8	4	3(8), 2.5(4)
26	0	0.5	0	0.5(12)
27	22	5	4	5(12)
28	12	2.4	3	2(2), 2.5(10)
29	18	3.6	5	3.5(10), 4(2)
30	18	4.9	7	5(10), 4.5(2)

Trip Generation Data obtained from Survey

APPENDIX 7 –TIME ARRIVAL SCHEDULE AT BUS STOPS

Time	1	2	3	4	5	6	7	8	9	10	11	2	1
7.45	7.46	7.47	7.48	7.49	7.5	7.51	7.53	7.55	7.56	7.57	7.58	7.59	8
7.5	7.51	7.52	7.53	7.54	7.55	7.56	7.58	8	8.01	8.02	8.03	8.04	8.05
8	8.01	8.02	8.03	8.04	8.05	8.06	8.08	8.1	8.11	8.12	8.13	8.14	8.15
8.15	8.16	8.17	8.18	8.19	8.2	8.21	8.23	8.25	8.26	8.27	8.28	8.29	8.3
8.3	8.31	8.32	8.33	8.34	8.35	8.36	8.38	8.4	8.41	8.42	8.43	8.44	8.45
8.45	8.46	8.47	8.48	8.49	8.5	8.51	8.53	8.55	8.56	8.57	8.58	8.59	9
8.5	8.51	8.52	8.53	8.54	8.55	8.56	8.58	9	9.01	9.02	9.03	9.04	9.05
9	9.01	9.02	9.03	9.04	9.05	9.06	9.08	9.1	9.11	9.12	9.13	9.14	9.15
9.15	9.16	9.17	9.18	9.19	9.2	9.21	9.23	9.25	9.26	9.27	9.28	9.29	9.3
9.3	9.31	9.32	9.33	9.34	9.35	9.36	9.38	9.4	9.41	9.42	9.43	9.44	9.45
9.45	9.46	9.47	9.48	9.49	9.5	9.51	9.53	9.55	9.56	9.57	9.58	9.59	10
9.5	9.51	9.52	9.53	9.54	9.55	9.56	9.58	10	10.01	10.02	10.03	10.04	10.05
10	10.01	10.02	10.03	10.04	10.05	10.06	10.08	10.1	10.11	10.12	10.13	10.14	10.15
10.15	10.16	10.17	10.18	10.19	10.2	10.21	10.23	10.25	10.26	10.27	10.28	10.29	10.3
10.3	10.31	10.32	10.33	10.34	10.35	10.36	10.38	10.4	10.41	10.42	10.43	10.44	10.45
10.45	10.46	10.47	10.48	10.49	10.5	10.51	10.53	10.55	10.56	10.57	10.58	10.59	11
10.5	10.51	10.52	10.53	10.54	10.55	10.56	10.58	11	11.01	11.02	11.03	11.04	11.05
11	11.01	11.02	11.03	11.04	11.05	11.06	11.08	11.1	11.11	11.12	11.13	11.14	11.15
11.15	11.16	11.17	11.18	11.19	11.2	11.21	11.23	11.25	11.26	11.27	11.28	11.29	11.3
11.3	11.31	11.32	11.33	11.34	11.35	11.36	11.38	11.4	11.41	11.42	11.43	11.44	11.45
11.45	11.46	11.47	11.48	11.49	11.5	11.51	11.53	11.55	11.56	11.57	11.58	11.59	12
11.5	11.51	11.52	11.53	11.54	11.55	11.56	11.58	12	12.01	12.02	12.03	12.04	12.05
12	12.01	12.02	12.03	12.04	12.05	12.06	12.08	12.1	12.11	12.12	12.13	12.14	12.15
12.15	12.16	12.17	12.18	12.19	12.2	12.21	12.23	12.25	12.26	12.27	12.28	12.29	12.3
12.3	12.31	12.32	12.33	12.34	12.35	12.36	12.38	12.4	12.41	12.42	12.43	12.44	12.45
12.45	12.46	12.47	12.48	12.49	12.5	12.51	12.53	12.55	12.56	12.57	12.58	12.59	13

Time	1	2	3	4	5	6	7	8	9	10	11	2	1
13	13.01	13.02	13.03	13.04	13.05	13.06	13.08	13.1	13.11	13.12	13.13	13.14	13.15
13.15	13.16	13.17	13.18	13.19	13.2	13.21	13.23	13.25	13.26	13.27	13.28	13.29	13.3
13.3	13.31	13.32	13.33	13.34	13.35	13.36	13.38	13.4	13.41	13.42	13.43	13.44	13.45
13.45	13.46	13.47	13.48	13.49	13.5	13.51	13.53	13.55	13.56	13.57	13.58	13.59	14
13.5	13.51	13.52	13.53	13.54	13.55	13.56	13.58	14	14.01	14.02	14.03	14.04	14.05
14	14.01	14.02	14.03	14.04	14.05	14.06	14.08	14.1	14.11	14.12	14.13	14.14	14.15
14.15	14.16	14.17	14.18	14.19	14.2	14.21	14.23	14.25	14.26	14.27	14.28	14.29	14.3
14.3	14.31	14.32	14.33	14.34	14.35	14.36	14.38	14.4	14.41	14.42	14.43	14.44	14.45
14.45	14.46	14.47	14.48	14.49	14.5	14.51	14.53	14.55	14.56	14.57	14.58	14.59	15
14.5	14.51	14.52	14.53	14.54	14.55	14.56	14.58	15	15.01	15.02	15.03	15.04	15.05
15	15.01	15.02	15.03	15.04	15.05	15.06	15.08	15.1	15.11	15.12	15.13	15.14	15.15
15.15	15.16	15.17	15.18	15.19	15.2	15.21	15.23	15.25	15.26	15.27	15.28	15.29	15.3
15.3	15.31	15.32	15.33	15.34	15.35	15.36	15.38	15.4	15.41	15.42	15.43	15.44	15.45
15.45	15.46	15.47	15.48	15.49	15.5	15.51	15.53	15.55	15.56	15.57	15.58	15.59	16
15.5	15.51	15.52	15.53	15.54	15.55	15.56	15.58	16	16.01	16.02	16.03	16.04	16.05
16	16.01	16.02	16.03	16.04	16.05	16.06	16.08	16.1	16.11	16.12	16.13	16.14	16.15
16.15	16.16	16.17	16.18	16.19	16.2	16.21	16.23	16.25	16.26	16.27	16.28	16.29	16.3
16.3	16.31	16.32	16.33	16.34	16.35	16.36	16.38	16.4	16.41	16.42	16.43	16.44	16.45
16.45	16.46	16.47	16.48	16.49	16.5	16.51	16.53	16.55	16.56	16.57	16.58	16.59	17
17	17.01	17.02	17.03	17.04	17.05	17.06	17.08	17.1	17.11	17.12	17.13	17.14	17.15

Arrival Times of Scheduled Bus Service at all Proposed Bus Stops in UTP