Site Potentiality of Petrol Stations Based on Traffic Counts

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ABSTRACT

Site potentiality is an important factor that influences business success of a petrol station which relies on customer visits. In absence of the exact information on the number of customer visits, traffic volume can be chosen as a proxy to it through traffic-counts observation technique. A 2½-D surface of traffic volumes rendered using a regression model and geographic information system (GIS) can then be used to identify suitable sites for petrol stations. The study area is located within the Central Johor Bahru Municipality, Malaysia, covering the Mukim of Pulai and a part of Mukim of Senai-Kulai. Based on the model developed, it was found that sites along expressways have the greatest influence on traffic volume followed by situs accessibility, road direction to commercial areas, and segment's population density. Overall, the predictive ability of the model was quite satisfactory. A GIS map of predicted site potentiality was then generated to guide on the spatial choice for locating petrol stations in the study area.

Keywords: *traffic volume, geographic information system (GIS), multiple regression analysis (MRA), petrol station*

1.0 INTRODUCTION

Taken together, the industrial, residential, and commercial sectors make up 51.7% of petrol demand in Malaysia (Nineth Malaysia Plan, 2006). This indirectly indicates the importance of spatial existence of these three types of urban land use in determining the success of petrol business across a particular region. Consequently, suitable sites for petrol stations must be assessed in relation to the locations of these urban zones besides other situs characteristics.

The aim of this study is to assess site potentiality for petrol station business based on traffic volume counts using a regression and Geographic Infromation System (GIS) based spatial analysis. In this context, this study has three objectives. Firstly, to briefly review physical characteristics that influence the level of traffic volume at a particular site; secondly, to specify a regression model that produces parametric estimates of these characteristics for predictive purpose; and finally to incorporate the model into a GIS to render a 2½-D contour map of predicted traffic volume counts in a study area to assess site potentialiy for petrol stations.

Section 2 presents the theoretical background of the study. Section 3 outlines the study area, data and methods. Section 4 discusses the results and findings. Finally, section 5 concludes the paper.

2.0 THEORETICAL BACKGROUND

2.1 Concepts

A petrol station is a retail establishment where motor vehicles are refueled, lubricated, serviced, and sometimes repaired (Friedman, 1978). Most petrol stations sell petrol or diesel, some carry specialty fuels such as liquified petroleum gas (LPG), natural gas, hydrogen, biodiesel, kerosene, or butane while the rest add shops to their primary business, and convenience stores (The American Heritage Dictionary, 2004). Meanwhile, petrol retailer or entrepreneur is any person who carries on a business which sells petrol for direct delivery into the fuel tanks of motor vehicles (Sedgwick, 1969).

Traffic volume is the number of vehicles on a roadway (Anon, 2003) while traffic volume count is a count mode of the number motor vehicle passing a precise point during a specified period of time (Arnold, 1993). Traffic volume count data are normally used in connection with a marketing study to determine the likelihood of success for real estate operation such as service station, automatic laundry, fast food restaurant, retail store, and so forth. However, the raw traffic count data must be evaluated by experts to determine how much effective demand it will actually produce (Arnold, 1993).

A site is said to have a potential if it has the capacity to develop into something in a future or something possessing the capacity for growth or development (Oxford Dictionary of English, 2003). Accordingly, site potentiality is the potential condition or quality, which has the possibility as opposed to actuality, or possible power or capacity with regards to a given site (adapted from Barnhart and Barnhart, 1992). Thus, site potentiality in this study is the inherent ability or capacity and economic potential of a site – given its situs characteristics – to generate certain level of traffic volume from passing vehicles.

2.2 The Importance of Location to Petrol Filling Station

Petrol stations are very vulnerable to closure resulting from petrol price competition, regulatory pressure and non-strategic location (Sidaway, 1998). As the classical adage used to advise, “location, location, location” remain the most important factors when choosing a home or positioning our business (Waters, 2003). George Davies made a strong point in his autobiography that setting a shop in the wrong place is like tying hands behind one’s own back (Davies, 1991, as cited in Clarke, 1995). Thus, choice of a location is the single most important decision facing retailers and service providers (Jones et al., 2003). Location is repeatedly stressed in the business press as a requirement for success in retailing (Chan et al., 2005). This is because location can affect business competition and performance, hence, level of profitability.

Theoretically, a firm would choose locations that maximize profits. Location should be considered as a relevant growth determinant (Hoogstra, 2004). It affects many aspects of petrol station operation and can significantly affect the economy of the local community (Mudambi, 1994). Through a review of previous literature, Henry (2001) suggested that being an independent business owner or manager, one has to try to maximize benefits by controlling the location of outlets and market threshold. This was supported by Kearny (1998) who stated that it was found in the U.S. that site location (71%) is the primary factor for the drivers to choose a petrol station.

Business profitability of a petrol station is influenced by a number of factors such as property maintenance and management, size of the site, neighbourhood business potential, grade of street and topography, visibility, compatibility of traffic flow, transient business potential, ease of approach, and special features of location (Friedman, 1978).

Quality of site location is usually associated with the type and volume of traffic flows passing the site, proximity to a major travel route, visibility from the road, time taken by drivers to slow down to enter the petrol station, general ability to attract customers, road direction or movement, artery types, and distance of catchment areas from residential neighbourhoods and so forth. These physical factors in a site location can make the difference between excellence, mediocrity, or failure in use for service station purposes. With respect to the distance of catchment areas from residential neighbourhoods, site proximity to the surrounding residential neighbourhoods can be expected to exert signicifant influence on a petrol station business. Site proximity to residential neighbourhoods would naturally induce higher traffic volumes and, thus, give better opportunities for vehicle drop-bys for petrol filling.

According to the planning criteria by the National Petroleum Malaysia (PETRONAS), a petrol station should be located within a growth centre or an urban area except in circumstances where it can be shown through appropriate studies that the need exists. In addition, the land should be zoned for commercial and/or industrial use. A petrol station is not allowed to be chosen on a site that will cause traffic obstructions. Therefore, a strategic location for petrol station should not interfere the traffic flow. Also, a petrol station should be located at a minimum of 100 feet from any residential building. In a residential area, a landscaped open area of 10 feet wide shall be provided along the rear property boundary and 15 feet wide along the side proper boundaries. A wide frontage and large driveway area offer a convenience to motorist, draw public attention to the site, and permit handling of a larger volume of business (Friedman, 1978).

Other than the physical factors, there are also strategic locational factors that will influence the potentiality of the petrol station. These factors are discussed as follows.

2.3 Pertinent Spatial Factors Affecting Traffic Volume

Two similar petrol stations situated on two different sites would almost certainly have a different amount of total sales. This may be attributed to the factors such as brand loyalty, amount of traffic flow, local population, etc. Other than the pulling factors, there are also pushing factors such as physical barriers that prevent motorists from entering the site, traffic lights which cause congestion, lack of visibility, etc. Therefore, there are various criteria in determining site potentiality for a petrol station. The following section elaborates on more important factors that can influence the success of a site for petrol filling stations as described by MPJBT (1998) and others.

2.3.1 Site Location.

There are commonly three types of site of a petrol station (MPJBT, 1998). Firstly, left, whereby the petrol station is situated off a street and it is accessible from that street only. Secondly, corner, whereby the petrol station is situated at a corner where two streets meet. It is accessible from both streets. Thirdly, T-Junction, whereby the petrol station might have a three-way position. It may be accessible from one or two streets.

2.3.2 Artery road types

Types of artery road such as principal, primary, secondary and minor road give rise to different levels of traffic volume. Normally, a principal and primary road will have a high traffic volume. It will determine the number of motorists that can drop by a petrol station. The larger the number of customers, the higher is the potentiality of the site to increase its profitability.

There are various types of artery road (MPJBT, 1998). Expressway is a major highway or road that connects a city or district to another. A primary road is a road with lesser traffic connecting intra-urban areas in a district. A secondary road links streets between principal and/or primary roads in a city. A minor road is a road carrying lesser traffic through a city. A special road is a linker road with special characteristics which connects sites such as shopping centres, parks, an expressway linker, or any other highly transient locations.

2.4 Population density

Population density is the average number of residents in a community per square mile (Arnold, 1993). The number of residents in an area is a demand factor for petrol, hence affecting the sales of a petrol station (Leibbrand, 1976). The Malaysian Property Market Report (2005) recorded about 14,699 and 582,505 total numbers of new supply and existing residential units respectively in the state of Johor. The increasing residential development influences the volume of traffic within that particular area, that is, due to the increasing population it indirectly increases the number of vehicles. The increase in car ownership has resulted in greater demand for petrol consumption. In the absolute terms, the household sector is expected to require the highest petrol share of about 76% of total demand in 2010. The growth in the household sector is a reflection of the projected number of cars per household (Leo Moggie, 1985).

2.5 Accessibility

Accessibility is the ease of entry to and exit from a particular site of residential area. It also measures the ease of entry and exit for motorists on a station's side of the primary street. Petrol sales potential varies depending on such degree of accessibility, but if a station is to achieve its maximum potential it must be easy for motorists to see it and to enter it (Sedgwick, 1969). Some researchers claim that location decision involves a large fixed investment (Jones, 2003). Therefore, a common conclusion based on the preceding arguments and previous location theory (Jones, 2003; Henry, 2001; Mudambi, 1994; Hoogstra, 2004) is that, to ensure success, the enterprises and services should be sited in locations that allow easy access and that attract the largest number of customers.

The variables that should be considered when measuring accessibility include the number of traffic lanes, traffic speed and congestion, and traffic control devices. The larger the number of lanes on a station's side of the primary street, the more difficult the motorists from the outer lane to enter the petrol station. Traffic speed and congestion will also affect sales volume of a petrol station. If the traffic speed is high, motorists may probably miss the station. If the traffic is too congested, motorists will find it difficult to enter and make exit from the petrol station. Traffic lights situated near a petrol station will also decrease the number of motorists entering the petrol stations. This is so because a slow traffic flow is just another form traffic congestion which cause some motorists to avoid using roads with such a problem.

2.6 Direction/ movement of road

If the direction/movement of the road where a site is located is heading towards the central business district, commercial area, or industrial area, a petrol station may attract a high traffic volume. If the direction of the road is heading towards a small residential area, the number of customers and flow of traffic are slow. In this case, petrol sales seem to be closely related to movement of people in automobiles (Friedman, 1978).

2.7 Geographical Information System (GIS)

GIS can be looked upon as a computer software, hardware, data and personnel to help manipulate, analyse, and present information, that is tied to a spatial or geographic location (Shayya, 2004). This is a very general definition, and to expand it, GIS is defined as a computer system which stores digital data representing features on the earth and maintains attribute database for each feature (Brail & Klosterman, 2001). It is a tool that allows for the processing of spatial data into information and is used to make decisions about some portion of the earth (DeMers, 2000 in Shayya, 2004). GIS is very popular with the function of integrating spatial data and attribute data (Clarke, 1995; DeMers, 2000; Randall et al., 2005; and Taher, 2006).

This technology has been in existence since the 1960's, although the techniques used by GIS predate this (DeMers, 2000). The popularity of GIS and its tools was initially inhibited by the expense and expertise required to set up a system. GIS was developed when the demand for data on topography and other specific themes of the earth surface has accelerated greatly in many disciplines (Miles & Ho, 1999).

GIS has been widely applied to many disciplines including forestry, agriculture, environment, transportation, utilities and land information (Brail & Klosterman, 2001). Later, it began to be used for a broader array of business and management functions such as logistics, site and facilities management, marketing, decision making, and planning. The fact that businesses and public sector organisations have begun to use GIS is not surprising, particularly given the fact that much of the data that organisations typically use include significant spatial components, estimates range between 50% and 85% (Mennecke,1996). Because of these and other reasons, an increasing number of businesses have begun to make substantial use of GIS for a variety of routine decision support and analysis applications (e.g., market and demographic analyses).

Much research examining locational issues use an application of GIS in their analyses. GIS is important for entrepreneur to understand the demand catchments for their petrol stations (where customers come from), and the geodemographic structure of their catchments (what type of customers they are likely to receive) (Clarke, 1995). GIS technology reflects many of the trends in other sectors of the information system marketplace (Clarke, 1995).

2.8 Multiple Regression Model (MRA)

MRA is the collection of statistical and econometric methods specifically geared for dealing with problems of spatial dependence and spatial heterogeneity encountered in cross-sectional and panel data sets (Anselin, 2002). It is a well-established statistical technique which has been investigated and applied extensively for a long time (Gallimore et al., 1994; Dunse and Jones, 1998). It is a technique which seeks to link the value of a number of independent variables to a variable whose value is supposedly dependent on them (Gallimore et al., 1994). The intention is to produce a model, or an equation, which will explain this relationship and hence enable prediction of the dependent variable in cases when it is unknown.

The relationship between the level of traffic volume and its situs factors can conveniently be expressed as a regression phenomenon. The relationship is commonly proposed to make use of the spatial characteristics of variables to improve models (Gao et al., 2006). The general equation can be expressed as follows:

$$V = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \ldots\ldots\ldots + \beta_n x_n$$

where V = traffic volume; x = independent variables (access, artery, local population size, direction, site location; β_0 = constant; and $\beta_1 \ldots. \beta_n$ regression coefficients.

2.9 Integration between GIS and MRA

GIS plays a vital role in market analysis and petrol station's location planning (Clarke, 1995). Most of the advanced entrepreneurs/investors appreciate the applications of GIS as a strategic value of investment in spatial decision-support systems. Commercial and residential real estate, more than any other sector of our economy, are sensitive to location, and consequently, the ability to measure the impact of location is critical (Thrall, 1998). Only with the advent of GIS has it become possible for real estate professionals to measure the true impact of location and then make appropriate judgments based on the knowledge of that impact. Formal locational analysis that was unattractive to practitioners in the past because of its complexity and cost is now becoming more attractive because of the heightened productivity in the GIS industry associated with the overall technological transformation of the personal computer industry.

Randall et al., (2005), use GIS to generate map graphic and park boundaries across their study area. The park road network was added to the map using ArcView shape files provided by the FHWA/NPS Road Inventory Program (RIP) in order to gather traffic flow information. In addition a GIS was also used to create point locations for each traffic count, and to associate the traffic count with the appropriate road segment in the DMTI and DRA street networks (Setton et al., 2005). In addition, GIS imposes a consistency on data collection and data analysis. GIS value maps are introduced as a means of displaying variations in value at the individual property level (Wyatt, 1996).

Site location questions in real estate are best addressed when GIS is used in conjunction with formal locational analysis (Birkin et al., 1998). GIS without formal locational analysis, would become a ''black box'' and would be more detrimental than beneficial. Therefore, the integration between GIS and MRA is very valuable to make the spatial analysis more successful. This process included developing a site observation database, compiling GIS layers representing spatial distributions of environmental variables recorded for known sites, and examining the data with descriptive statistics. The statistical results were used to decide the environmental layers to use for model calculations and the model parameters. Finally, the model was run and results were visualized in GIS format.

Many researchers have applied GIS and regression analysis as their research methodology. For example, Mendes et al., (2006), has applied regression analysis to classify a new potential site for supermarket and evaluates different aspect of store location assessment. Li et al., (2000) have applied a regression analysis for identifying factors affecting seasonal traffic fluctuation in southeast Florida. Hernandez and Bennison (2000) carried a study regarding the use of particular types of techniques (ie; cluster, multiple regression, and gravity model) in locational analysis, and adoption of GIS which act as a platform for them. They found that the potential of using GIS to operationalise location techniques had improved the quality and analytical capabilities of techniques used, and allowed them to migrate from simple intuitive measures to actually analysis and modeling the retail environment. Gallimore et al., (1994) also make use of GIS to consider how the calibration of one crucially important, and invariably problematic, variable namely locations are determined.

Spatial statistics within a GIS, based on digitized map, have made possible the development of accurate, consistent, and unbiased explanatory variables, such as accessibility to petrol stations, in a fast and efficient manner (Taher, 2006). These can then be used to better measure the environmental characteristic of petrol stations, and to increase the understanding of petrol stations profitability variations. Sharma (1994) suggests that the selection of study method should be determined based on the count period. The count period should be representative of the time of day, day of month, and month of year for the study area. Typical count periods are 15 minutes or 2 hours for peak periods, 4 hours for morning and afternoon peaks, 6 hours for morning, midday, and afternoon peaks, and 12 hours for daytime periods (Robertson, 1994). Normal intervals for a manual count are 5, 10, or 15 minutes (Akes et al., 2004). For example, if conducting a 2-hour peak period count, eight 15-minute counts would be required.

Manual counts normally require a small sample of data at any given location. Manual counts are sometimes used when the effort and expense of automated equipment are not justified. Furthermore, manual counts are necessary when automatic equipment is not available and other mechanical equipment cannot be readily installed (Weiner, 1974). According to Akes et al. (2004), there are three types of traffic manual counts methods: tally-sheet method; mechanical counting boards; and electronic counting boards. In this study, the tally-sheets method is selected.

2.10 Traffic Volume Counts Method

Traffic volume studies are conducted to determine the number, movements, and classification of roadway vehicles at a given location (Weiner, 1974). These data can help identify critical flow time periods, determine the influence of large vehicles or pedestrians on vehicular traffic flow, or document traffic volume trends (Akes et al., 2004). The length of the sampling period depends on the type of count being taken and the intended use of the data recorded. There are two methods available for traffic volume counts, namely manual method and automatic method. Manual counts are typically used to gather data for determination of vehicle classification, turning movements, volume traffic, direction of travel, pedestrian movements, or vehicle occupancy (Akes et al., 2004). According to Weiner (1974), manual traffic counts are used to obtain flow in traffic surveys. Manual counts method are typically used for periods of less than a day. Automatic counts are typically used to gather data for determination of vehicle hourly patterns, daily or seasonal variations and growth trends, or annual traffic estimates (Akes et al., 2004).

3.0 STUDY AREA, DATA AND METHODS

3.1 Study Area

It is located within the Central Johor Bahru Municipality Council (Figure 1). It covers the Mukim of Pulai and part of Mukim Senai-Kulai. The area was selected for its fast-expanding suburb area in Johor Bahru. The sampling design was based on a geo-coded grid method. Within a particular grid, road segments were cut into sections. Then, a random sampling was done across the 360 grids to select 50 random points for traffic counts (Figure 2).

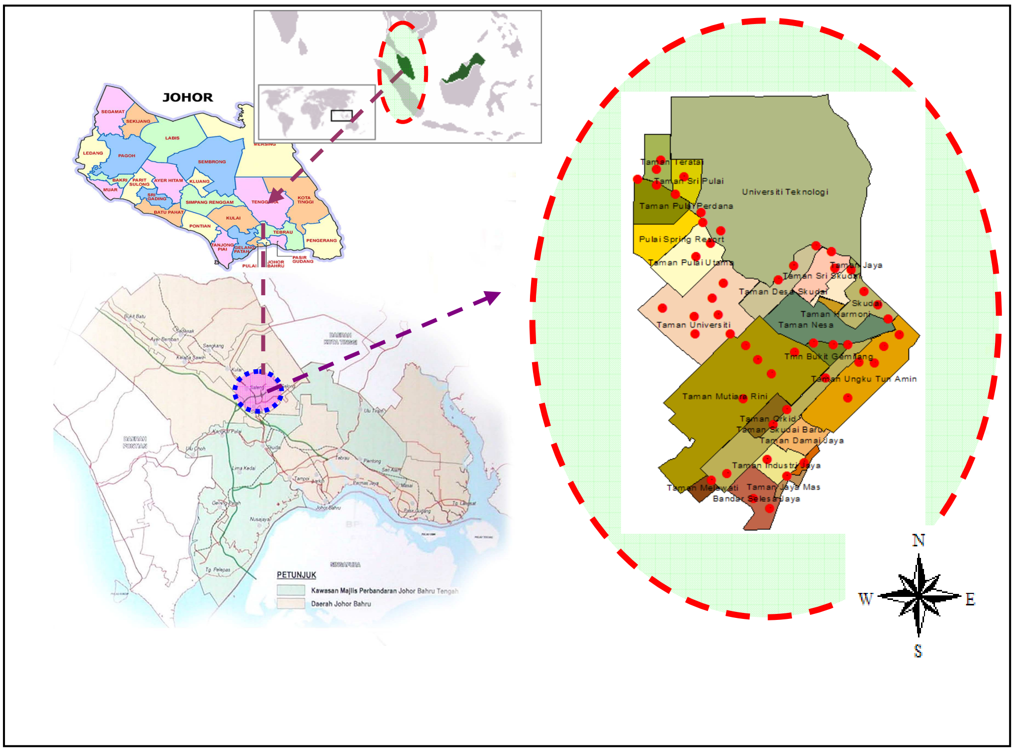

Figure 1: Map of Study Area

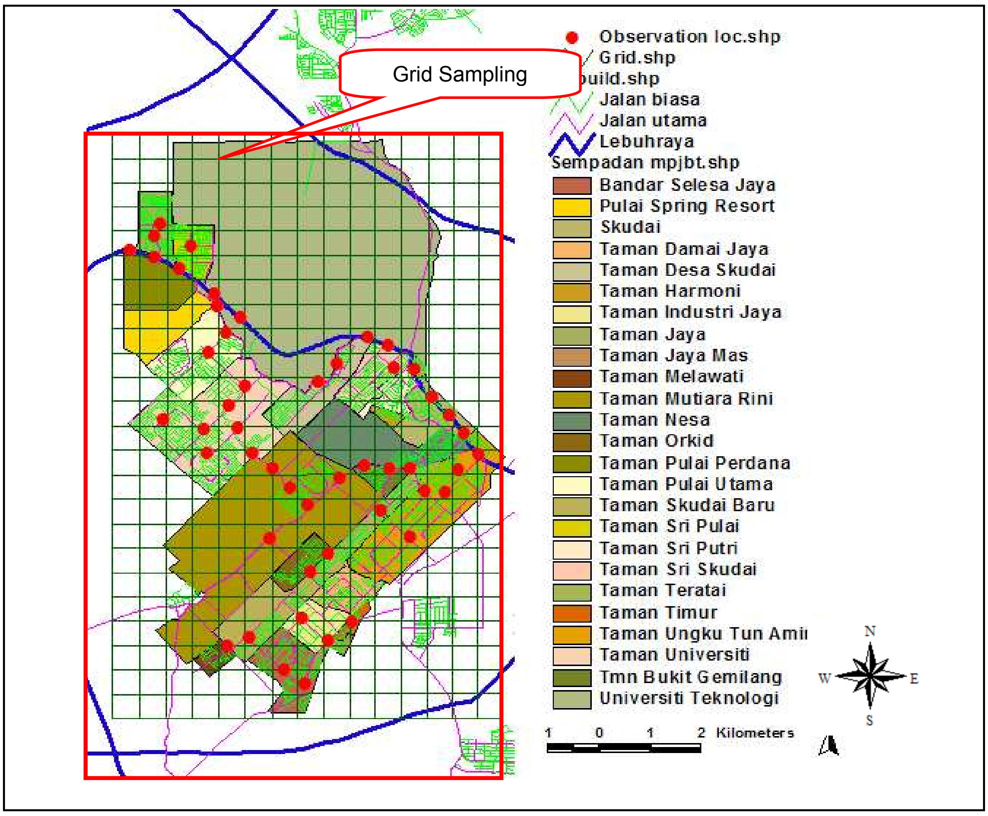

Figure 2: GIS Grid-Based Random Sampling

3.2 Data Method

Manual traffic volume counts were carried out to determine the number of vehicle passing across fifty randomly selected points in the study area. The traffic volume counts were performed on weekdays and weekends. At each observation point, the counting period was divided into 5 main time-blocks, from 0700 to 2200 hours (15 hours per day), with every block allocated with a 15-minute counting interval. This 15-minute counts were then converted into a 15-hour period per day.

Site characteristics which potentially influence the volume of traffic flow were observed, assessed and recorded at each of the fifty points. Every point wais linked to its attributes data, such as traffic volume counts, accessibility, artery road (name, type, length, and speed), population (m^2), site location, direction, and zoning. Functions such as identify and query were used to retrieve the attributes data. The traffic volume contour map was developed from these points. Besides, land use information (e.g. commercial, residential, industrial, open space) was used to determine sites and neighbourhood land use types. Since the direction of road movement is one of the factors that might influence the level of traffic volume, land use information helps determine whether a particular roadway moves towards a residential or commercial area.

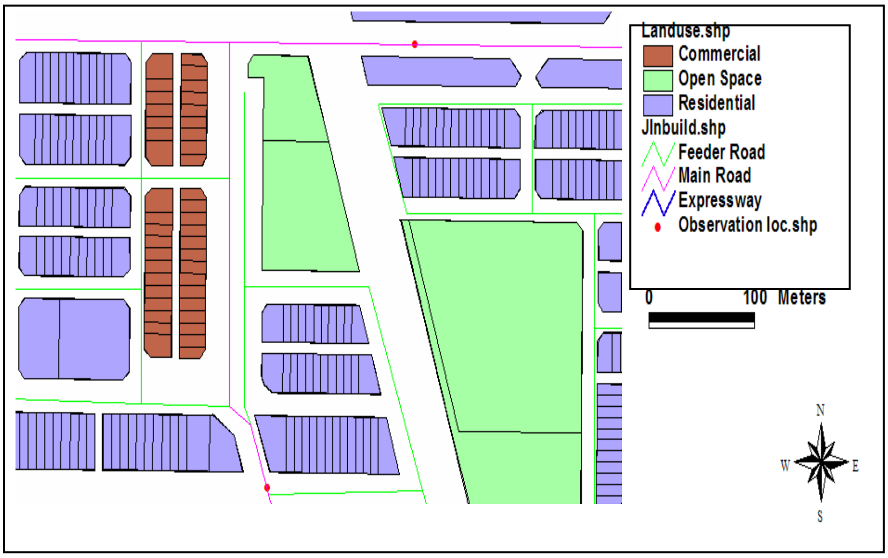

Figure 3: Example of building lots and land use

The developed GIS map also contained spatial information of building lots (Figure 3). Since population theoretically influences traffic volume, building lot information is essential. This information is useful in determining the population or density of a specific residential area. The value generated from the formula was computed as estimated population for the corresponding residential area. However extra care is required to count the number of building lots in order to generate a more precise figure. [The formula is: Population size = Size of building area/Size of residential area.] This method was used in this study as population data for the study area was not available from the related government agency.

Buffer analysis was used to obtain information from the GIS map to indicate the potentiality of captured area within a specified radius. For example, as illustrated in Figure 4, the site observation number 27 is able to capture customers from Taman Universiti, Taman Desa Skudai, Taman Nesa and Taman Mutiara Rini, within a 500-m radius of catchment area.

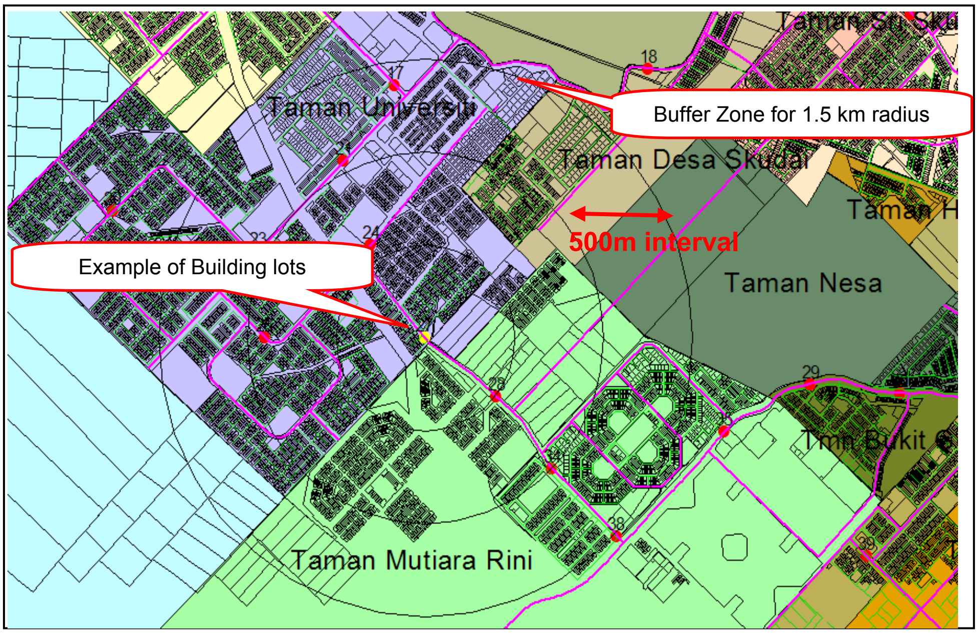

Figure 4: Example of Buffer Analysis

3.3 The Model

Five pertinent independent variables representing situs characteristics were specified in the multiple regression model (Table 1). They were specified with a view to examining their influence on the levels of traffic volume at all randomly selected points of observations. Geographic Information System (GIS) was also used in the analysis mainly to represent geographical data and to generate information for the regression.

Table 1: Regression Variables

VARIABLES	MEASUREMENT	DECRIPTION
Traffic volume at observed point (TV)	Actual observed data	For 15 hours data
Situs accessibility (ACCESS)*	Dummy variable	1 = Good 0 = Poor
Type of passing artery road (ARTERY)	Dummy variable	1 = Expressway 0 = Others
Segment's population (POPU)	People/sq. km.	Population in a specific area
Situs type of observed point (TYPE)	Dummy variable	1 = On left of roadside 0 = Others
Road direction at observed point (DIREC)	Dummy variable	1 = To CBD / commercial area 0 = To Residential

* For the purpose of this study a good accessibility is defined as a road having no more than three lanes on one side, not too many traffic lights at the observed point, and no physical barriers of entry or exit.

4.0 RESULTS AND DISCUSSION

4.1 Correlation and Regression Outcomes

A pairwise correlation coefficient of less than 0.800 is considered to be indicating no collinearity (Gupta, 1999). Therefore, the result shows no evidence of pairwise multicollinearity among the independent variables (Table 2).

Table 2: Pairwise Correlations of the Independent Variables

Factor	Access	Artery	Popu	Type	Direct
Access	1.000	-0.171	-0.390	0.107	-0.390
Artery		1.000	0.253	0.350	0.331
Popu			1.000	0.114	0.067
Type				1.000	-0.390
Direct					1.000

The model was found to be highly significant, on the basis of F-value, with the five independent variables explaining 97% locational variability in traffic volume, on the basis of R^2 (Table 3). Except for situs type, all the independent variables significantly influenced the level of traffic volume. With regard to situs type, a petrol station located on the left side of a road may not necessarily generate a high traffic volume. A non-enclosed expressway could have generated the highest traffic volume, followed by situs accessibility, and direction of road movement to city, commercial, and/or industrial areas. All variables have influenced the level of traffic volume positively.

Table 1: Regression results (Dependent: traffic volume)

R^2	0.970	
Adj. R^2	0.966	
F-value	280.217	
SSE	9,792,756	
SEE	1,165.73	
Sample size	50	
Variable	Coefficient	t-value
Constant	847.074	1.812
ACCESS	1,329.178	3.503
ARTERY	13,980.507	30.013
POPU	0.417	2.311
TYPE	156.184	0.385
DIREC	765.171	2.146

Good sites accessibility could have added 1,329 passing vehicles more than a similar site of a less sites accessibility. A non-enclosed expressway could have potentially added as many as 13,980 units of vehicles on a comparable site more than other types of artery road. An increase in a segment's (500-m radius) population by one person will increase traffic volume by 0.417 vehicle unit. Interestingly a site on the left side of a road virtually makes no difference compared to the one located at a t-junction or a corner. However, if the direction or movement of a road where a petrol station is located is heading towards a CBD, commercial, or industrial area, the site may have a greater potential to generate a higher traffic volume, namely 765 vehicle units compared to a comparable site heading towards residential neighbourhoods.

4.2 Site's Traffic Volume Count Prediction

In-sample prediction discrepancies between the observed and predicted traffic volume counts were quite moderate whereby there were fourteen excessive over- or under-predicted sites (discrepancy 30% and above) (Table 4). Most of these "poorly predicted sites" were sites located at feeder roads within housing neighbourhoods. This means, the level of traffic volume, its pattern, and sites factors affecting both at such sites need to be more thoroughly studied and modelled. In the same way, "well-predicted sites" (discrepancy around 10%) may need to be thoroughly studied as well. This means, there is still room for modelling improvement of site potentially for petrol station business.

Table 4: Weekdays' Observed and Predicted Levels of Traffic Volume

Obs	*Roadway Name*	*Observed TV*	*Predicted TV*	*Error*		*Rank*
				Number	*%*	
2	Expressway Pontian	20,704	17,511	3,086	18	1
5	Expressway Pontian	20,120	17,743	2,295	13	2
19	Jln Skudai	18,728	17,440	1,245	7	3
6	Expressway Pontian	18,704	17,238	1,644	10	4
9	Expressway Pontian	17,216	17,469	-609	-3	5
7	Expressway Pontian	16,816	17,469	-1,009	-6	6
22	Jln Skudai	16,592	16,167	438	3	7
16	Jln Skudai	16,572	17,531	418	3	8
11	Expressway Pontian	16,240	17,260	-2,061	-11	9
33	Jln Skudai	14,544	16,392	-1,769	-11	10
25	Jalan Skudai	14,352	15,704	-1,147	-7	11
12	Expressway Pontian	13,528	16,195	-2,539	-16	12
17	Jln Perdagangan	5,108	3,220	1,011	25	13
4	Jln Sri Pulai	4,472	3,468	1,280	40	14
24	Jln Kebudayaan	4,376	4,463	1,452	50	15
37	Jln Tun Aminah	3,784	3,634	466	14	16
38	Jln Persiaran Utama	3,744	3,450	588	19	17
3	Jln Teratai	3,632	1,975	246	7	18
21	Jln Pendidikan	3,556	4,463	-697	-16	19
8	Jln Pontian Lama	3,436	1,615	928	37	20
28	Jln Kebangsaan 68	3,412	2,756	1,195	54	21
27	Jln Kebangsaan 68	3,408	4,000	-139	-4	22
41	Jln Tun Aminah	3,376	3,434	214	7	23
32	Jln Tun Teja	3,308	3,634	-10	0	24
1	Jln Rotan	3,032	2,206	-354	-10	25
18	Jln Pontian Lama	3,024	1,724	624	26	26

29	Jln Gelang Patah	3,016	3,002	490	19	27
23	Jln Pendidikan	2,960	2,758	957	48	28
26	Jln Kebudayaan	2,880	2,526	-452	-14	29
39	Jln Tun Aminah	2,784	3,157	244	10	30
14	Jln Pontian Lama	2,764	1,724	364	15	31
35	Jln Gelang Patah	2,656	2,988	265	11	32
30	Jln Gelang Patah	2,632	3,002	106	4	33
34	Persiaran Utama	2,600	2,787	365	16	34
31	Jln Gelang Patah	2,568	3,264	-775	-23	35
36	Jln Pewira 16	2,508	3,634	-810	-24	36
15	Jln Emas Putih 5	2,344	2,395	-1,005	-30	37
13	Jln Pulai 19	2,092	2,109	304	17	38
10	Jln Persiaran Pulai Utama	1,928	2,109	-1,189	-38	39
50	Jln Selesa Jaya	1,776	1,920	-797	-31	40
40	Jln Sri Orkid	1,704	1,976	33	2	41
47	Jln Selesa Jaya	1,692	2,972	-685	-29	42
45	Jalan Silat Lincah	1,664	1,883	453	37	43
42	Jln Hang Jebat	1,660	1,651	-880	-35	44
49	Jln Silat Lincah	1,648	1,688	404	33	45
46	Jln Selesa Jaya	1,536	2,765	-680	-31	46
43	Jln Hang Jebat	1,516	1,683	-868	-36	47
48	Jln Melawati	1,384	1,714	-261	-16	48
20	Jln Penyiaran	1,032	2,958	-2,456	-70	49
44	Jln Hang Lekir	908	1,222	55	6	50

4.3 2½-D Site Potentiality Mapping

The main purpose of developing traffic volume 2½-D contour map is to visualize the differences between observed and predicted traffic volume data. An extension of "3D Analyst" in the ArcView GIS was used to produce a 2½-D contour map. Two sets of observed traffic volume data namely weekday and weekend observation data, and also one set of predicted traffic volume data (weekday) which were derived from the derived model were used.

Displaying the traffic volume data in a 2½-D view has some advantages. Firstly, it is convenient to visualize areas with certain characteristics of traffic volume (e.g. patterns and levels of traffic across an area). Secondly, it allows fast decision-making as to the suitable sites for locating a petrol station.

Figure 5 shows a tree-top 2½-D view of observed traffic counts in the study area. Traffic volume regimes are depicted using colour differentiation of elevation range. The highest and lowest traffic volumes are represented by red (18,001-21,000 vehicle units) and grey (500 – 1,000 vehicle units), respectively. Most of the highest traffic counts were located along the expressway while the lowest traffic counts were located along main roads in southern part of the study area.

4.4 Predicted Weekdays' and Weekends' Traffic Volumes

The predicted levels of traffic volume were obtained from the regression model as shown in Table 3. The geographic views of predicted levels traffic volume are shown in Figures 7 and 8. It was found that the profiles of predicted traffic volumes were similar to those observed (Figures 5 and 6). Some results are shown in Table 5. Again, areas located off the non-enclosed expressways or main roads exhibited less traffic volumes. This was so because areas located in the southern part of the study area are not the main focal points of mainstream traffic. Furthermore, population size in those areas is comparatively smaller.

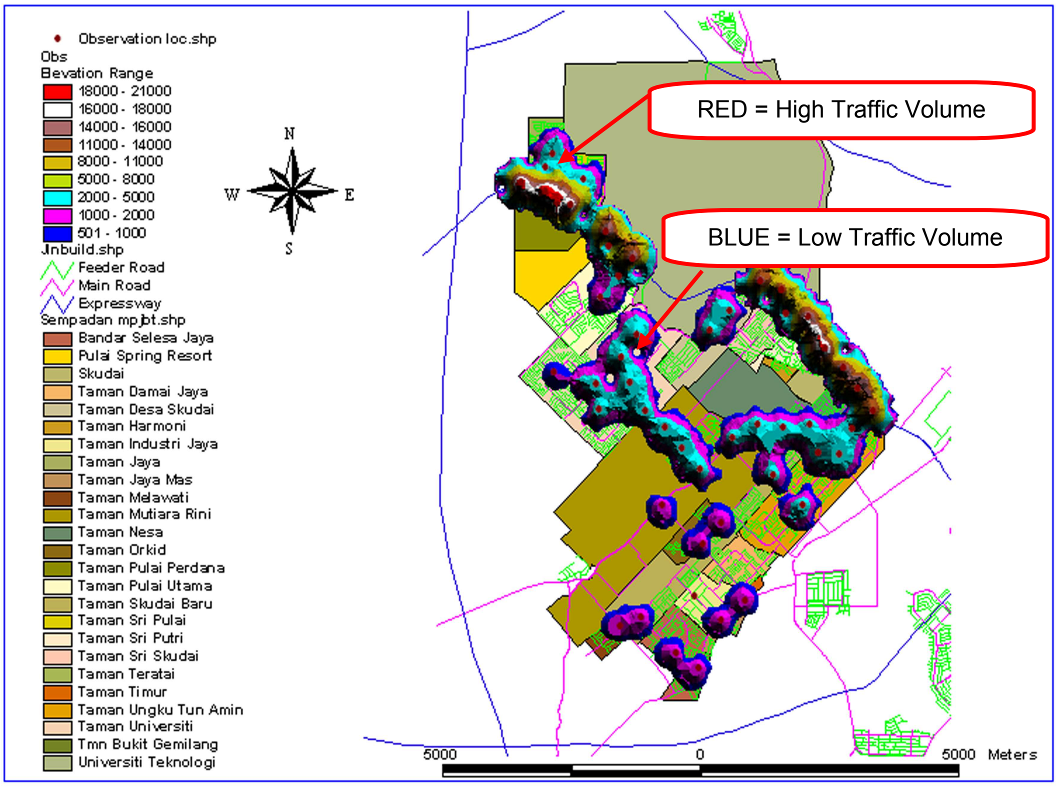

Figure 5: A Tree-Top 2½-D View of Observed Weekdays' Traffic Volumes – View 1

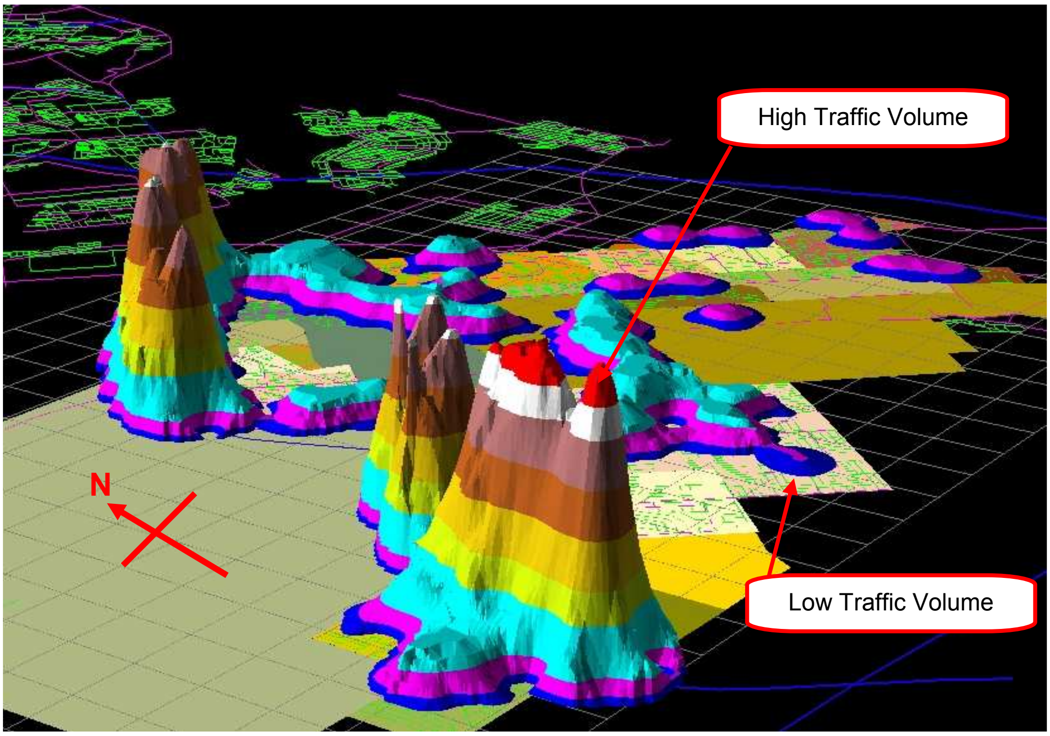

Figure 6: 2½-D View of Observed Weekdays' Traffic Volume – View 2

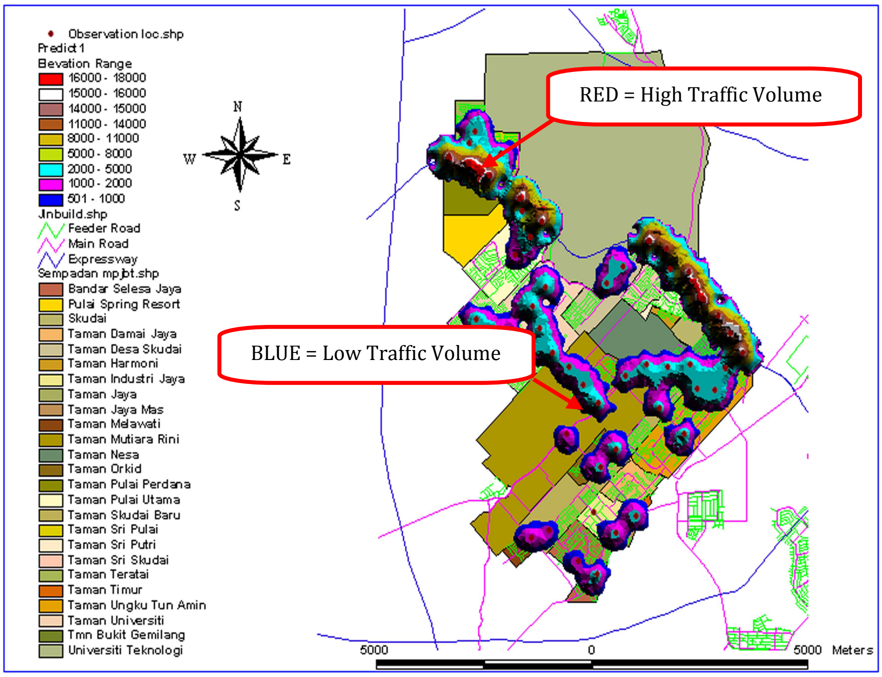

Figure 7: A 2½-D View of Predicted Weekdays' Traffic Volume – View 1

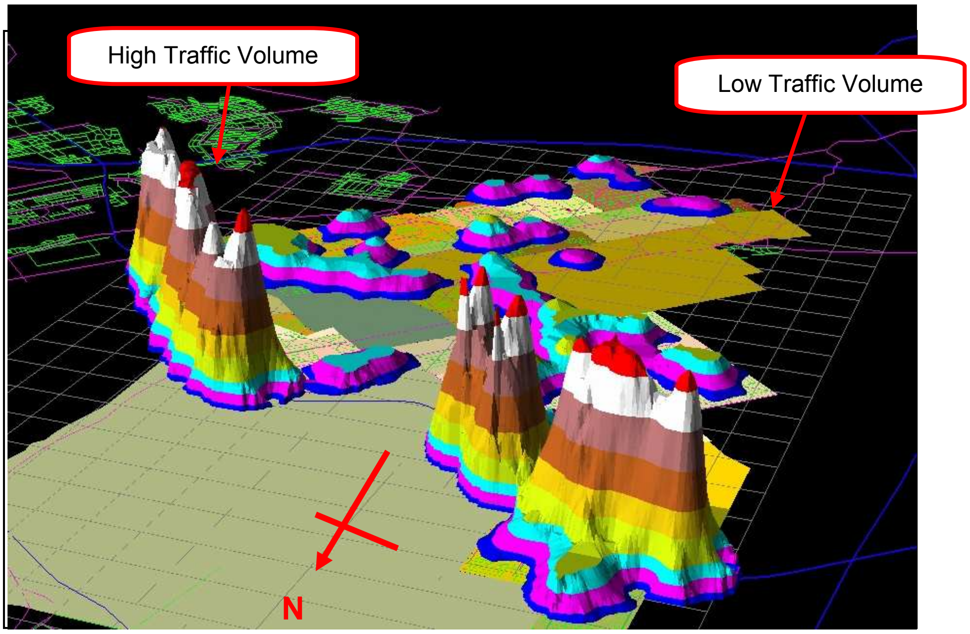

Figure 8: 2½-D View of Predicted Weekdays' Traffic Volume – View 2

Table 5: Differences between Weekdays and Weekends' Traffic Volumes

Site	*Road stretch*	*Observed TV (Weekdays)*	*Observed TV (Weekends)*	*Differences (%)*
1	Jalan Rotan	3,032	1,352	16.8
2	Expressway Pontian	20,704	11,088	96.16
3	Jln Teratai	3,632	1,748	18.84
4	Jln Sri Pulai	4,472	2,080	23.92
5	Expressway Pontian	20,120	10,188	99.32
6	Expressway Pontian	18,704	9,820	88.84
7	Expressway Pontian	16,816	9,856	69.6
8	Jln Pontian Lama	3,436	2,008	14.28
10	Jln Persiaran Pulai Utama	1,928	1,876	0.52
13	Jln Pulai 19	2,092	1,940	1.52
14	Jalan Pontian Lama	2,764	2,068	6.96
17	Jln Perdagangan	5,108	2,892	22.16
18	Jln Pontian Lama	3,024	1,956	10.68
21	Jln Pendidikan	3,556	2,148	14.08
23	Jln Pendidikan	2,960	2,052	9.08
24	Jln Pendidikan	4,376	2,452	19.24
26	Jln Kebudayaan	2,880	2,168	7.12
27	Jln Kebudayaan	3,408	2,420	9.88

4.4 Applying the Regression Model to Predict Traffic Volume

To further evaluate its predictive ability, the model was applied to other areas. Two existing petrol stations located at Jalan Tun Teja, in Taman Ungku Tun Aminah were taken for example, namely, Caltex and BP petrol stations (Figure 8.19). Both are located within a moderately populated neighbourhood.

The actual levels of traffic volume observed at jalan Tun Teja were 3,308 vehicle units. Using the regression model, the predicted level of traffic volume for both Caltex and BP petrol stations was 3,634 vehicle units (i.e., 8.97% over-prediction). [Both petrol stations have the same accessibility condition, types of artery road, population ize , situs type, and direction of road movement.] While the BP petrol station has suffered a dramatic reduction in traffic drop-bys three year after starting its operation, the Caltex which was established much earlier enjoyed a good patronage for many years. However, our field visit later discovered that both petrol stations were closed down in 2008.

The BP failure to attract customers may be explained by the situs characteristics of the petrol station itself. The surface of the site where the petrol station was built is below the road level. This can affect visibility and ease of entry (Friedman, 1978., Sedgwick, 1969). Apart from that, the BP brand might be less popular compared to the Caltex brand. Boyle (2002) states that brand strength results in added value and therefore increased competitive advantage for the retailer. In addition, the petrol station's physical characteristics and services such as the size can also give a different attraction to customers (Sedgwick, 1969). Other than that, the number of pumps, the service hours, the types of pump service (attendant service or self service), the differences in services provided such as kiosk, parking lot, car wash service, and ATM services (Kearny, 1998) also could have influenced traffic drop-bys. Thus, while a statistical-GIS based model can serve as a basis for traffic volume prediction, further analysis on the basis of individual sites must always be made before final site assessment is made.

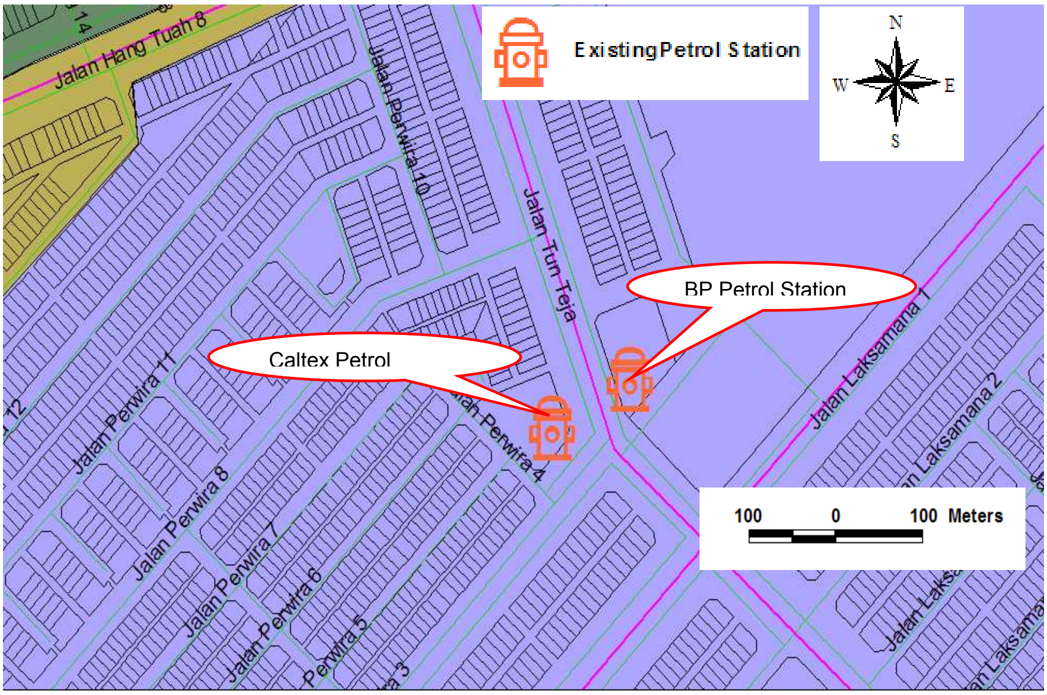

Figure 9: Location of Petrol Stations for Model Predicive Test

5.0 CONCLUSION

The right location for a petrol station is important for the good performance of a firm and its profitability (Jones et al., 2003; Hoogstra and Dijk, 2004). Using a regression model, it is possible to estimate the effects of situs characteristics on traffic volume, which is a principal element of a petrol station's income. Besides, the variables included in a regression model can partly be determined with the help of a GIS map. Integration between a GIS and a regression model allows for an analytical approach to be adopted for spatial decision-making.

By using GIS map, site planning becomes more significant for its visualisation capability. Any decision-making process which makes use of spatial information may potentially get benefit from the use of GIS (Clarke, 1995). GIS also provides integrated information on urban neighbourhoods and their locational attributes with respect to urban traffic flows. The output produced via GIS can be linked to the analysis of petrol station business and its neighbourhood characteristics. Overall, the technique discussed in this study would be of a great help in the operational decisions in property planning, development, marketing, valuation, management, and investment.

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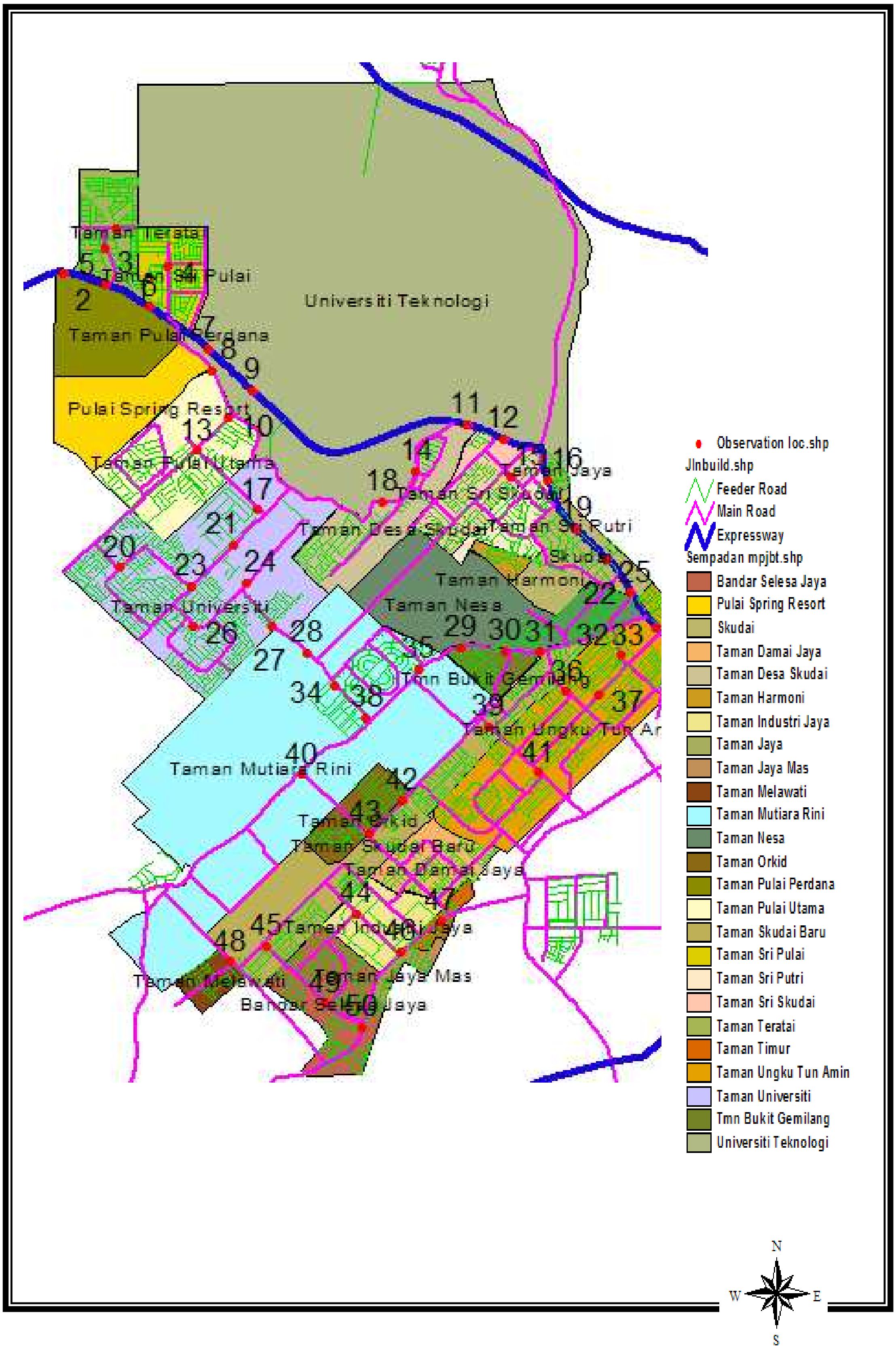
APPENDIX : STUDY AREA MAP



List of site

Site	*Nameof road*	*Name of housing estate*
1	Jln Rotan	Taman Teratai
2	Expressway Pontian	Taman Pulai Perdana
3	Jln Teratai	Taman Teratai
4	Jln Sri Pulai	Taman Sri Pulai
5	Expressway Pontian	Taman Pulai Perdana
6	Expressway Pontian	Taman Pulai Perdana
7	Expressway Pontian	UTM
8	Jln Pontian Lama	Taman Pulai Utama
9	Expressway Pontian	UTM
10	Jln Persiaran Pulai Utama	Taman Pulai Utama
11	Expressway Pontian	Taman Desa Skudai
12	Expressway Pontian	Taman Sri Skudai
13	Jln Pulai 19	Taman Pulai Utama
14	Jln Pontian Lama	Taman Desa Skudai
15	Jln Emas Putih 5	Taman Sri Skudai
16	Jln Skudai	Taman Sri Putri
17	Jln Perdagangan	Taman Universiti
18	Jln Pontian Lama	Taman Desa Skudai
19	Jln Skudai	Skudai
20	Jln Penyiaran	Taman Universiti
21	Jln Pendidikan	Taman Universiti
22	Jln Skudai	Skudai
23	Jln Pendidikan	Taman Universiti
24	Jln Kebudayaan	Taman Universiti
25	Jalan Skudai	Skudai
26	Jln Kebudayaan	Taman Universiti
27	Jln Kebangsaan 68	Taman Universiti
28	Jln Kebangsaan 68	Taman Mutiara Rini
29	Jln Gelang Patah	Taman Bukit Gemilang
30	Jln Gelang Patah	Taman Bukit Gemilang
31	Jln Gelang Patah	Taman Bukit Gemilang
32	Jln Tun Teja	Tmn Unku Tun Aminah
33	Jln Skudai	Tmn Unku Tun Aminah
34	Persiaran Utama	Taman Mutiara Rini
35	Jln Gelang Patah	Taman Mutiara Rini
36	Jln Pewira 16	Tmn Unku Tun Aminah
37	Jln Tun Aminah	Tmn Unku Tun Aminah
38	Jln Persiaran Utama	Taman Mutiara Rini
39	Jln Tun Aminah	Tmn Unku Tun Aminah
40	Jln Sri Orkid	Taman Mutiara Rini
41	Jln Tun Aminah	Tmn Unku Tun Aminah
42	Jln Hang Jebat	Taman Skudai Baru
43	Jln Hang Jebat	Taman Skudai Baru
44	Jln Hang Lekir	Taman Industri Jaya
45	Jalan Silat Lincah	Taman Skudai Baru
46	Jln Selesa Jaya	Taman Jaya Mas
47	Jln Selesa Jaya	Taman Timur
48	Jln Melawati	Taman Melawati
49	Jln Silat Lincah	Bandar Selesa Jaya
50	Jln Selesa Jaya	Bandar Selesa Jaya