ALTERNATE ROUTE ALLOCATION FOR TRAFFIC MANAGEMENT AND CONGESTION MITIGATION ON ISLAMABAD EXPRESSWAY

A thesis submitted in partial fulfilment of

the requirements for the degree of

BACHELORS OF
CIVIL ENGINEERING

NUST Institute of Civil Engineering

School of Civil and Environmental Engineering

National University of Science and Technology, Islamabad, Pakistan

2018


بسم الله الرحمن الرحيم

DEDICATED

TO

OUR FAMILY, TEACHERS AND COLLEAGES

This is to certify that the

Final Year Project, titled

ALTERNATE ROUTE ALLOCATION FOR EMERGENCY TRAFFIC MANAGEMENT ON ISLAMABAD EXPRESSWAY

Submitted by

Hasnain Abrar	NUST-201432259
Gohar Butt	NUST-201432881
Najam-ul-Hassan	NUST-201432790
Zain-ul-Abidin	NUST-201433041

Has been accepted towards the requirements

for the award of Bachelor's degree

in

CIVIL ENGINEERING

_____

Malik Kamran Shakir
Lecturer

Table of Contents

List of Tables

Table of Figures

LIST OF ACRONYMS

SB	South Bound
NB	North Bound
LOS	Level of Service
HCM	Highway Capacity Manual
N-5	National Highway-5
PCU	Passenger Car Unit
PHF	Peak Hour Factor

ACKNOWLEDGMENT

"In the name of Almighty Allah, the Most Beneficent, the Most Merciful"

First and foremost, all thanks and praises to ALLAH Almighty for the strength, patience, knowledge and His blessings to complete this project. We are obliged to our respected supervisor, Lecturer Malik Kamran Shakir who gave us his precious time and shared his life-long hard-earned knowledge and experience. During the project, there arose some serious issues but he guided us and helped us to tackle each situation. It would never have been possible for us to work on this project without his supervision, constant support and innovative instructions. I would also thank HoD Transportation for providing us with his assistance and resources.

We are also very thankful to our parents and families, as they prayed for us and motivated us in the hard times. Their support and affection was among the things that kept us going.

We express our profound gratitude to all our seniors who helped us bring the positive energy to surface by the productive discussions and support.

ABSTRACT

Expressway is a major arterial in Islamabad Capital territory. It was constructed in 1968 with purpose of connecting Islamabad capital to national highway N5. It stretches from Zero point to Rawat (T chowk). Recently a number of housing communities have been established alongside of Islamabad expressway. Most of these housing colonies provide affordable housing comparative to sectors of Islamabad which has diverted the attention of people towards these colonies. As a result the traffic on Islamabad highway has grown exponentially. Due to the increased traffic, congestion is a common problem on Islamabad Expressway nowadays resulting in major trip delays ranging to nearly 15-20 minutes. To cope with the traffic congestion problem alternate route strategy has been brought into account. The project will comprise on Devising alternate routes, Implementation of ITS for regulation of traffic and proper usage of these alternate routes and Simulation on VISSIM.

Chapter 1

INTRODUCTION

1.1 LOCATION

Islamabad highway with its total length of 24km stretches in North South direction connecting Kashmir Highway (zero point) to National Highway N5 near Rawat. It serves as one of the biggest access roads connecting Islamabad and Rawalpindi.

1.2 BACKGROUND

The metropolitan trio including Karachi, Lahore and Islamabad is reaching saturation level in terms of land availability because of the ever increasing population also the people are heading towards the cities due to majority of the reasons including safety, security, job opportunities, Better resources etc. Islamabad Rawalpindi Metropolitan is the third largest in Pakistan with a population exceeding 4 million (population census 2017). Due to increasing population and limited public transport especially in Islamabad major trend shift has occurred towards use of local cars for transport purposes. Pakistan is a flourishing market for Automobiles Company with sales reaching ever high 185,781 units mark (figures source Express tribune).

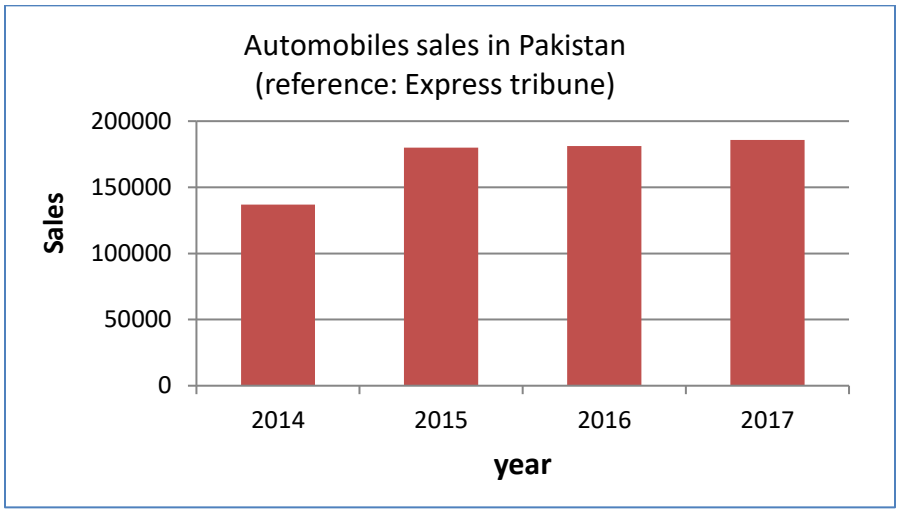

Figure 1: Automobile Sales in Pakistan

The increasing trend necessitates better road facilities with high capacity to cope with the travel and route demand as to reduce travel time. Failure to do so, the Level of service drops down noticeably leading to High congestions which is in other words failure for the facility previously designed for high speed movement. Islamabad highway is serving as one of the main connection route between Islamabad and Rawalpindi. Along its 24 km stretch from Zero point (Islamabad) to T-chowk (Rawat). Currently only about 13 km of the highway is upgraded into 5 lane road (each direction) while the rest of the stretch is 2 lane. In 2015 project for widening the highway to 5 lanes and modifying it to signal free corridor was inaugurated by the prime minister but it had been halted by CDA due to lack of funds. Because of the exceeding travel way demand and limited resources/budget, Islamabad highway is facing issues of high level congestions especially in the peak hours while the situation gets worse in case of accidents/breakdowns.

1.3 PROBLEM STATEMENT

Islamabad highway is serving as one of the main connection routes between Rawalpindi and Islamabad. Although it was proposed as an Expressway, having properties of signal free corridor and grade separated intersections but due to limited funds it wasn't designed for full length. Off the full length of 24km currently only 13km section is upgraded to 5 lanes which spans from Zero Point (Kashmir Highway) to Korang River Bridge near Gulberg greens. The rest is 2 lanes.

Due to increasing number of societies astride Islamabad highway with no restricted access the properties of Islamabad Highway matches to a Major arterial. The highway due to these massive traffic generators is experiencing heavy congestions due to one or more of the following reasons.

- Peak Hours congestion periods where a surge of traffic occurs from the offices, Universities etc. to Houses in evening or the reverse in morning.
- Large queue's resulted from the breakdown of any vehicle along the highway.
- Any blockage/strikes along the highway due to social, political reasons etc.

No proper strategy has been devised until now to address this congestion issue due to which during the above periods, loss of connection between Islamabad and Rawalpindi region occurs.

This congestion leads to one or more of the following problems.

- decreased speeds
- Increased vehicular queuing
- High fuel consumption
- Increased trip time
- Air and noise pollution.

All of which have a negative impact on drivers psychology rendering the driver frustrated and impatient.

1.4 OBJECTIVES

1. Congestion mitigation studies addressing the present as well as future demands.
2. Alternate Route allocation for Islamabad highway during congestion periods including both
    - Anticipated – Peak hour congestion periods
    - Unanticipated – Emergency situations
3. Proposals of Geometric design and layout of alternate routes (if needed).
4. Introduction of Intelligent transportation system (ITS) for traffic management and control for both highway and alternate routes provided.
5. Efficient modeling and simulation of the complete system using VISSIM.

1.5 SCOPE

Our current study area is the un-widened section of Islamabad Expressway starting from Gulberg greens interchange till Rawat (T-Chowk) which entails to about 11 km in length. This area is facing high congestions due to a number of factors like

- Bottle neck situation due to conversion of 5 lanes to 2 lanes on Korang River Bridge. (Near Gulberg greens interchange)
- Three U-turns both protected and unprotected leading towards Housing societies.
- Traffic Signal nearby Soan Gardens.
- Slow traffic in front of housing societies entrances/exists on expressway.
- Slow traffic movement due to heavy traffic.
- Vehicle queuing due to break down of any vehicle.

A number of Housing colonies occur alongside Islamabad Highway namely

- Jinnah Gardens
- Naval Anchorage
- Soan Gardens
- Pak PWD
- Bahria Town
- Korang Town
- Pakistan Town
- Defense Housing Authority (DHA)
- Canyon views
- Media Town
- Doctor’s Housing Society

1.6 LIMITATIONS

Not an exact representation of the ongoing situation of the highway because of the limited hours for conduction of survey and the greater stretch of the highway but it still gives us a good overview.

Movement and Traffic counts on some minor intersections with movements less than 10 veh/min were omitted during calculations. For the exact picture, those could be added for more accurate result.

1.7 JUSTIFICATION FOR SELECTION OF TOPIC

Congestion is a common problem in any metropolitan worldwide. There are numerous ways to cater congestion which are

- Establishing a proper Public transport system addressing the user's demand which can ultimately reduce the traffic on the roads.
- Increasing the capacity by increasing number of lanes.
- Signalization integration to reduce the delay on each signal and traffic platooning.
- Alternate routes to divide the traffic on the routes.

Most feasible solution is widening of roadway which has also been carried out for Islamabad Highway till Gulberg green interchange. Ahead of that interchange there are about 3 bridges which incur high costs to the project due to which the project of widening the highway is temporarily halted.

The primary connectors of Islamabad and Rawalpindi are G.T road and Islamabad highway. Majority of the traffic travelling between Islamabad and Rawalpindi is divided among the two roads. By providing additional alternate routes we can efficiently reduce congestion on Islamabad Highway.

Chapter 2

LITERATURE REVIEW

Very limited work has been done in the field of planning and provisions of alternate routes in Pakistan.

The only solution majorly used in Pakistan to avoid congestion is by adding additional lanes thereby exceeding capacity of the facility. Although this procedure satisfy the demand but the increased capacity doesn't caters for the queue generated and hence related congestion due to any incident e.g. breakdown of vehicles, accidents etc. on the facility. Hence during these emergency situations the vehicles had to remain in the long queues unless the site is cleared.

Alternate routes have an upper hand because of the fact that other than division of traffic among different routes, traffic can be diverted to other routes in case one route blocks because of the incident.

Because of that limited study on alternate routes with no adjoining route near our study area we have to design the alternate routes as well along with integrating them through ITS. This has increased the scope of the project. Due to which we couldn't find any paper specific to our project. We had to acquire procedural elements from variety of papers; books etc. and formulate a methodology of our own.

Few of the papers and books studied for this purpose and the definitions used are summarized below.

2.1 Engineering terms definition:

2.1.1 Traffic Engineering

A branch of civil engineering that deals with the roads, streets design and construction and uses engineering practices to assure the safe and efficient movement of people and goods on roadways.

2.1.2 Traffic Congestion

A situation occurring on transport networks in which its usage increases along with slower speeds, longer trip times, and increased vehicular queuing. It happens when traffic demand approaches the capacity of a road or of intersection and due to the interaction between vehicles, speed of moving vehicles slow down and congestion sets in. When the speed of vehicles is almost zero, a situation referred to as "traffic jam" occurs.

2.1.3 Average Daily Traffic

Average daily traffic or ADT, and sometimes also known as mean daily traffic, is the total volume of vehicles during a given time period (in whole days), more than one day and less than one year, divided by the number of days in that time period.

2.1.5 Traffic Count

A traffic count is counting of vehicles along a particular road, it can either done electronically (JAMAR counter etc.) or manually using Traffic Count Sheets.

2.1.6 Passenger Car Unit (PCU)

Passenger Car Unit (PCU) is a metric used in Transportation Engineering, used for expressing highway capacity. A Passenger Car Equivalent is basically the impact that a mode of transport has on traffic variables (such as headway, speed, density) compared to a single car. For example, typical values of PCU (or PCE) are:

Table 2.1: Equivalent Passenger Car Units for each class as defined by AASHTO, Green Book.

VEHICLES	**PCU/PCE**
Car (including taxis, jeeps, land Cruisers, Hiace, Wagons, Minibus, Mazda)	1.0
Motorcycles, Rickshaw, Qingqi, Bicycle	0.5
Large Bus (>3o seats)	3.0
All Trucks including construction vehicles	4.0
Tractors with or without trolley	5.0

2.1.7 Peak Hour Factor

One hour period is the accepted unit of time for expressing flow rate. The total hourly volume that can be served without exceeding a specified degree of congestion is equal to or less than four times the maximum 15- minutes count. The factor used to convert the rate of flow during the highest 15-minute period to the total hourly volume is the peak hour factor. (PHF).

2.1 CASE STUDIES

2.2.1 Alternative route strategy for emergency traffic management

The paper was a case study of Xiang Ming City wall. The paper was focused on utilization of existing routes as alternatives for the main Corridor. Advanced Traveler information/management system was introduced for accident detection and diversion strategies upstream of the accident location were generated by integrating ITS based model.

The important and vulnerable locations were determined first. And the final decisions incorporated alternative route excess capacity, travel time and driver's personnel favorites.

Following procedure was followed.

- Real time traffic data collection and processing
- Incident monitoring and detection
- Alternative route choice
- Alternative route guidance

The whole process was simulated on synchro software while the experimental network of locality was generated through VISSIM.

2.2.2 Real time traffic diversion model: conceptual approach

The paper was the case study of Northern Virginia Urban Area.

Two types of automated incident detection model (AID'S) were presented namely

- Pattern Recognition model
- Time series model

California Algorithm model (Pattern recognition model) was used for the case study because of its simplicity and high detection rate.

Procedure involved following steps

a. Incident Report generation
   Involved time, place and type of occurrence and its associated details
b. Delay estimation module
   Involved calculation of time till normal flow. It included
   - Detection time
   - Response time
   - Clearance time
   - Getaway time
c. Following module was presented for the Real time diversion advisory system.

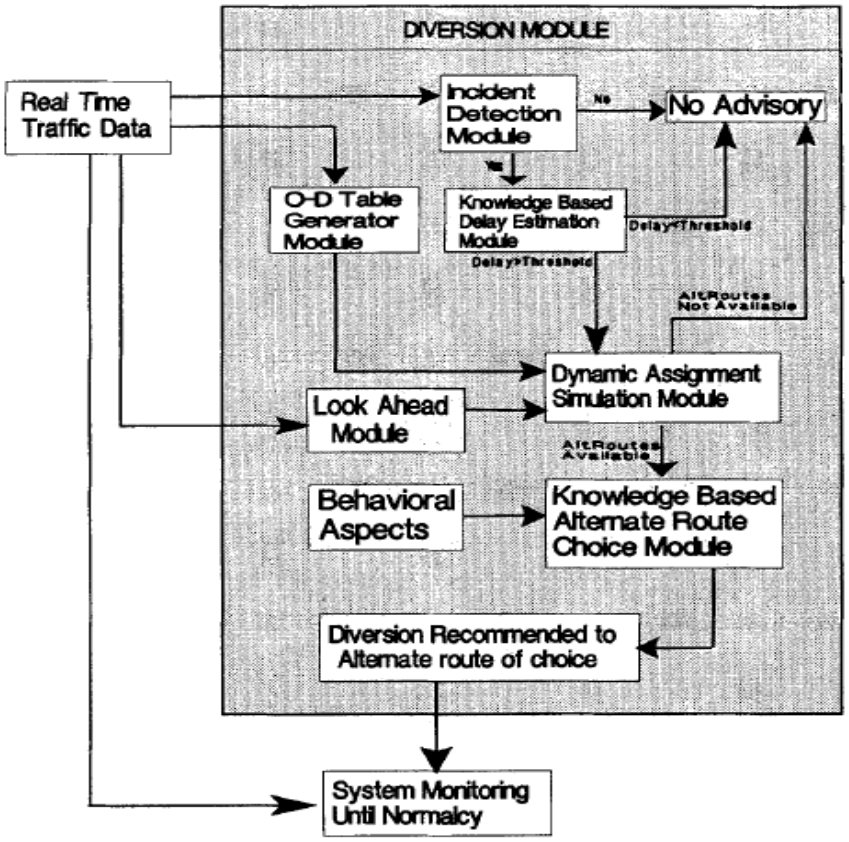

Figure 2: Block Diagram of Processes Involved in a Real-Time Diversion Advisory System

Chapter 3

METHODOLOGY

1. Describing study area, defining the In/out Junctions (extremes of highway), inner intersections (selected) and the major traffic generators.
2. Mapping the routes using AutoCAD and locating any alternate route (if present).
3. Origin destination trips study for the area

   Survey – Filling of Survey form by the drivers requiring information from each driver about their commencement location and destination. Usually done for a sample and hence not usually followed.

   License Plate Survey- License plate matching technique is followed. Also occurs for a small sample.

   Traffic counts – Traffic data collection through manual traffic counts on each inlet/outlet junction, intersections and traffic generators during peak hour. Manual counts are done for all the traffic (Population rather than sample). More effective and hence used in design. We will also follow this process.
4. Highway zoning based on V/C and complemented through manual perception and using Google maps as follows.

Table: Zoning guide

Zones	Type	Details	V/C	LOS	Legend
Zone '1'	High Congestion zone	• Long queues generated. • Minimal dissipation in time.	> 0.8	E-F	
Zone '2'	Moderate congestion zone	• Medium length queues. • Dissipated in short time if conditions permit.	0.6-0.8	C	
Zone '3'	No congestion zone	• No or short length queues. • Occurs for few minutes.	<0.6	A-B	

Table 1: Zoning Guide

5. Locating the probable zones of high congestion (potential intersections) and identifying the cause of congestion.
6. Providing solutions and alternatives to minimize congestion and hence streamlining the whole flow on the highway. e.g.
    - Signal Optimization (reducing Cycle length to affordable limits) to reduce queuing length. If distance between traffic signals is less traffic platooning by modulating the traffic signals.
    - Reducing protected movements (if not needed).
    - Removing U-turn signal phases by delineating a separate U-turn Lane.
    - If necessitated, proposal of on-grade intersections (approach towards signal free corridor).
    - Provisions of Auxiliary/acceleration lanes for merging and diverging traffic (if needed).
7. Formulation of a module which can detect congestion/accidents etc. and can safely and timely diverge traffic to alternate route serving as a guideline during implementation procedures. (Introduction of ITS).
8. Simulation of the whole operation on VISSIM.

3.1 Area of Study:

Our Area of study includes the unwidened section of the Islamabad Highway which accounts for 11 km of the total highway. This section spans from Korang River Bridge near Gulberg interchange to T-Chowk and has major intersections of PWD, Kahuta Road, Soan Gardens, Naval Anchorage and DHA.

`

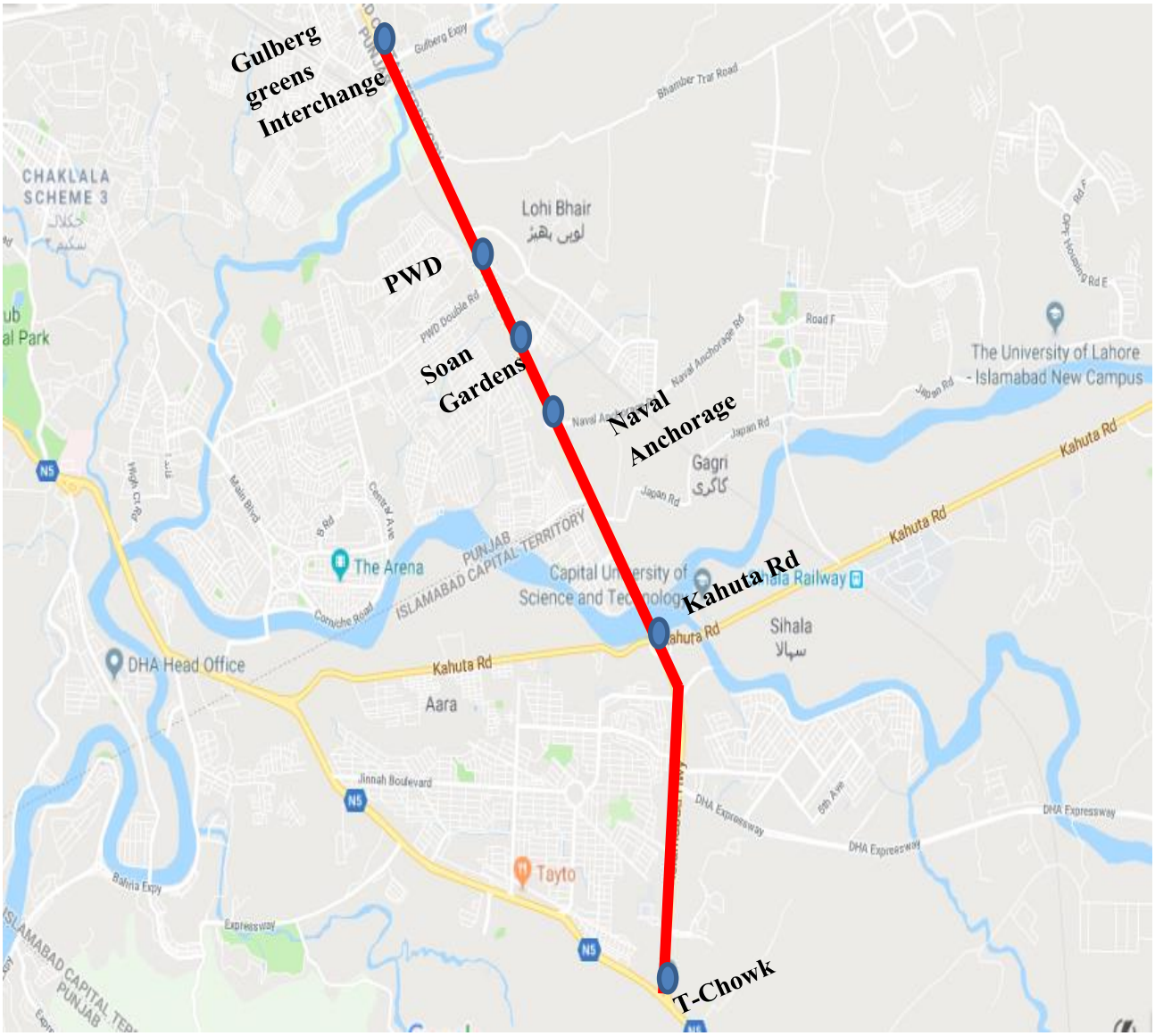

Figure 3: Area of Study

3.2 Mapping of Routes:

The Section of the highway was then mapped for the available routes using AutoCAD. The purpose was to check for already available routes that can serve as the alternate routes for Islamabad Highway.

It was found out that the roads in the vicinity are completely disjointed and hence they can't serve as alternate routes.

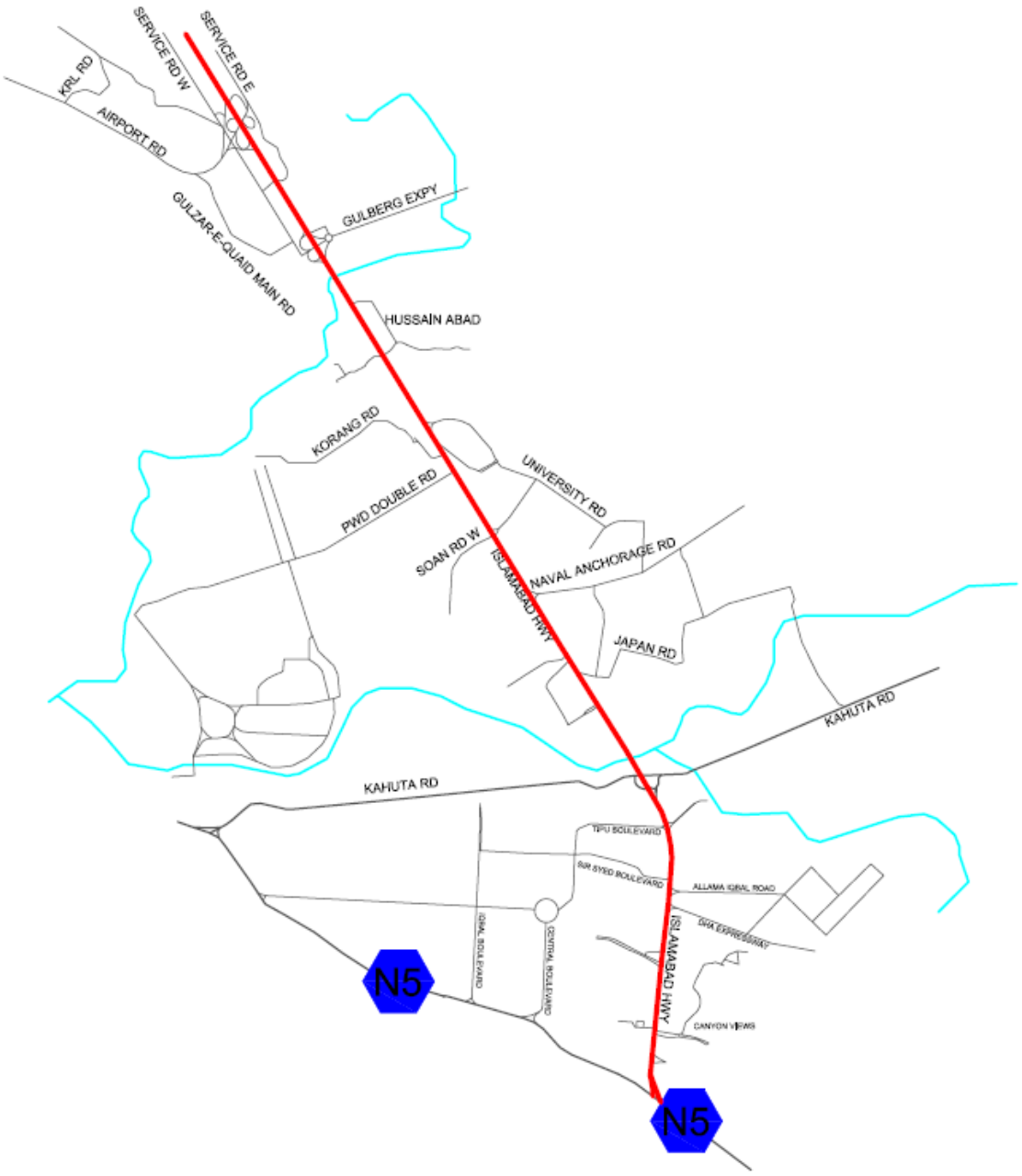

Figure 4: Route Mapping

3.3 Data Collection

3.3.1 Determining Major junctions and intersections

The Expressway was divided into six sections which were

- T-Chowk to DHA
- DHA to Kahuta Rd
- Kahuta Rd to Naval Anchorage
- Naval Anchorage to Soan Gardens
    - Before Soan Gardens U-turn
    - After Soan Gardens U-turn
- Soan Gardens to PWD
    - Before U-turn of PWD
    - After U-turn of PWD
- PWD to Gulberg greens Interchange

At each junction and intersection the movements were mapped.

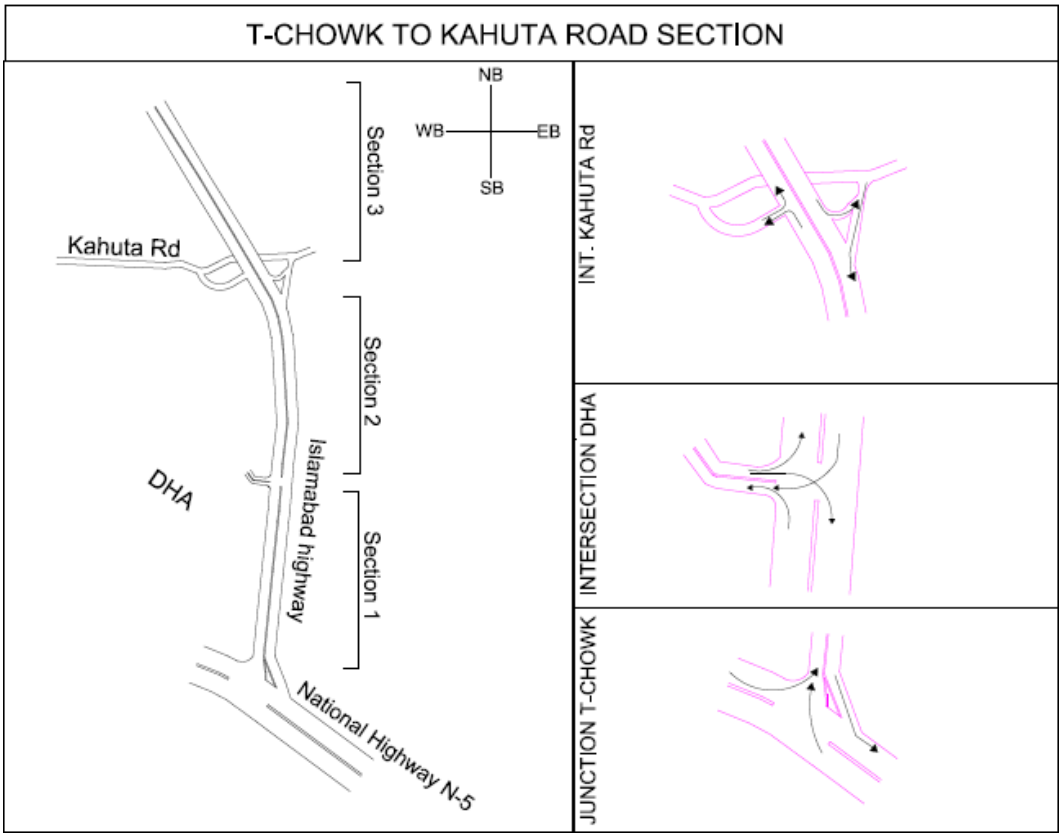

Figure 5: Route Movements

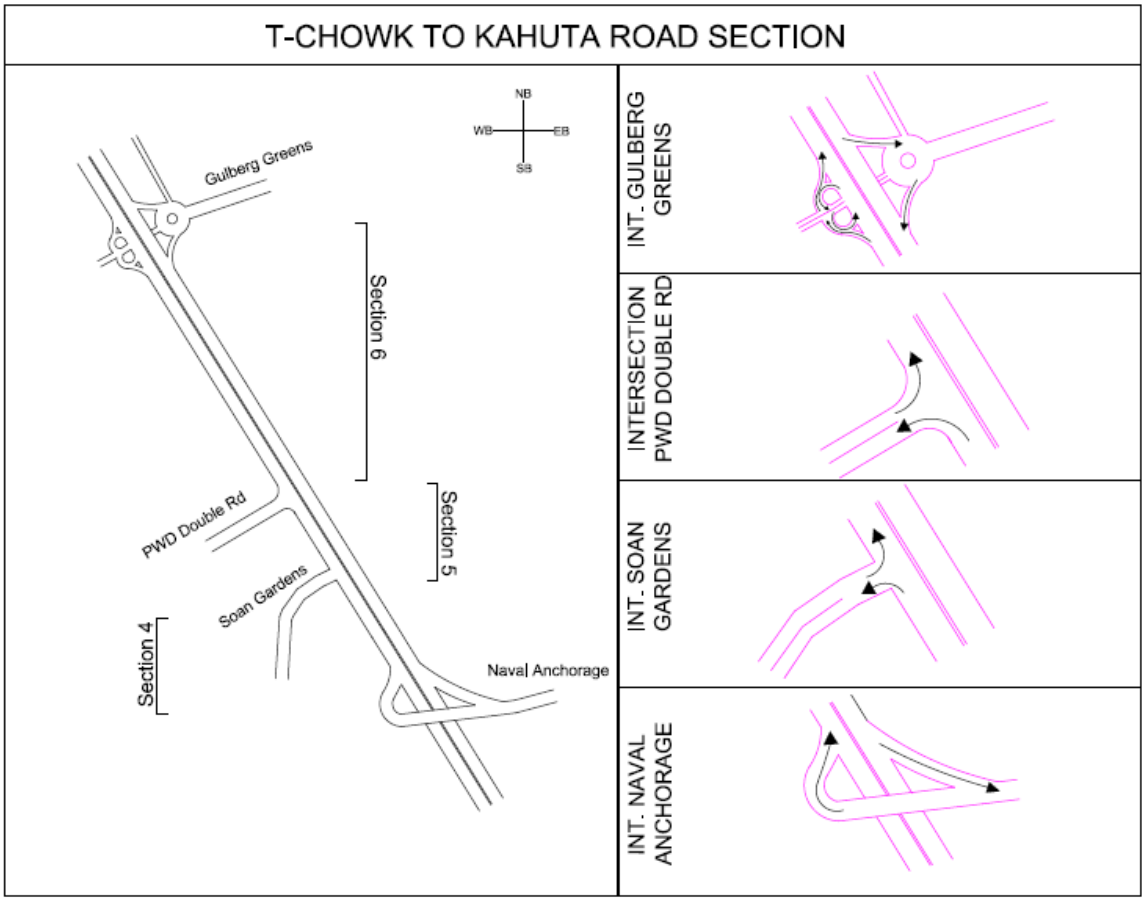

Figure 6: Route Movements

To determine the volume on each section for the peak hour manual traffic counts were conducted.

3.3.2 Manual Data collection

Tally sheets were used for the traffic counts.

Figure 7: Tally Marks

3.3.3 Manual Count Method

First of all traffic was segregated into following classes.

- **Motor Bikes**
- **Passenger Cars**
- **Hiace**
- **Buses**
  - Coasters
  - Public Transport Buses
- **Trucks**
  - 2-axle trucks
  - 3-axle trucks
  - 4-6 axle trucks
  - Tractors (with or without trolley)

3.3.4 Representative Day and Time Slot

Traffic counts on Tuesday, Wednesday and Thursday were taken to omit any exceptional behavior of high traffic volumes. The selected time slots were

MORNING	7:00 to 9:00 AM
EVENING	5:00 to 7:00 PM

3.3.4 Assigning PCU's

Passenger car units were assigned for each vehicle type referenced from the following table.

Vehicle Type & PCU

Type of Vehicle (Fast Moving Vehicle)	PCU Factor
Two Wheeler	0.5
Three Wheeler	1
Car / Jeep / Van / Taxi	1
Small or Medium Commercial Vehicle (SMV)	1
Light Commercial Vehicle (LCV)	1.5
Tractor without trolley	1.5
Tractor with trolley	4.5
Mini Bus	1.5
Bus	3
2 – Axle Truck	3
3 – Axle Truck	3
4 to 6 Multi Axle Truck	4.5
7 & More Multi Axle Truck	4.5
Other Vehicles (Earth, Agriculture, Forestry Moving Vehicle)	4.5

Table reference:
India 2010 vehicle present scenario

Table 2: PCU

3.3.5 Peak Hour Volume

After Assigning PCU's the peak hour was determined for the hour which yielded the max EPCU's.

3.3.6 Volume on highway

Knowing the inbound and outbound volumes at each intersection and junctions the Volume on the sections of highway was calculated just by arithmetic operations as seen in the following table.

Section	Section location		NB Flow (veh/hr)				SB Flow (veh/hr)			
			Existing Volume	Volume IN	Volume OUT	Final Volume	Existing Volume	Volume IN	Volume OUT	Final Volume
1	T-CHOWK TO DHA			1732		**1732**			1841	**1841**
2	DHA TO KAHUTA RD		1732	352	118	**1966**	1841	40	348	**2149**
3	KAHUTA RD TO NAVAL ANCHORAGE		1966	1112	444	**2634**	2149	393	799	**2555**
4	NAVAL ANCHORAGE TO SOAN GARDENS	Before U-turn Soan Gardens	2634	249	87	**2796**	2555	97	226	**2684**
		After U-turn Soan Gardens	2796	498	67	**3227**	2684	67	498	**3115**
5	SOAN GARDENS TO PWD	Before U-turn of PWD	3227	553	890	**2890**	3115	0	0	**3115**
		After U-turn of PWD	2890	1230	147	**3973**	3115	147	1230	**4198**
6	PWD TO GULBERG GREENS		3973	1185	1258	**3900**	4198	0	0	**4198**

Table 3: Current Scenario Volumes

3.6 LOS CALCULATION

After Assigning PCU's the LOS for the multilane was determined by using the formulas given by HCM.

$$v_p = \frac{V}{PHF \times N \times f_{HV} \times f_p}$$

where
V_p = 15 min passenger car equivalent flow rate (pcphpl)
V= Hourly volume (veh/hr)
PHF = Peak hour factor
N = No. of lanes
F_{HV} = Heavy vehicle adjustment factor
F_P = Driver Population factor

$$FFS = BFFS - f_{LW} - f_{LC} - f_N - f_{ID}$$

FFS = Free Flow Speed (mph)
BFFS = Base free flow speed 70 mph (urban), 75 mph (rural)
f_{lw} = adjustment for lane width (mph)
f_{lc} = Adjustment for right shoulder lateral clearance
f_N = Adjustment for no. of lanes
f_{ID} = Adjustment for interchange density

The density of the multilane segment was then calculated by taking the ratio of Vp and FFS.

$$D = V_p / S$$

This density obtained was then checked on the speed-flow curve for its LOS.

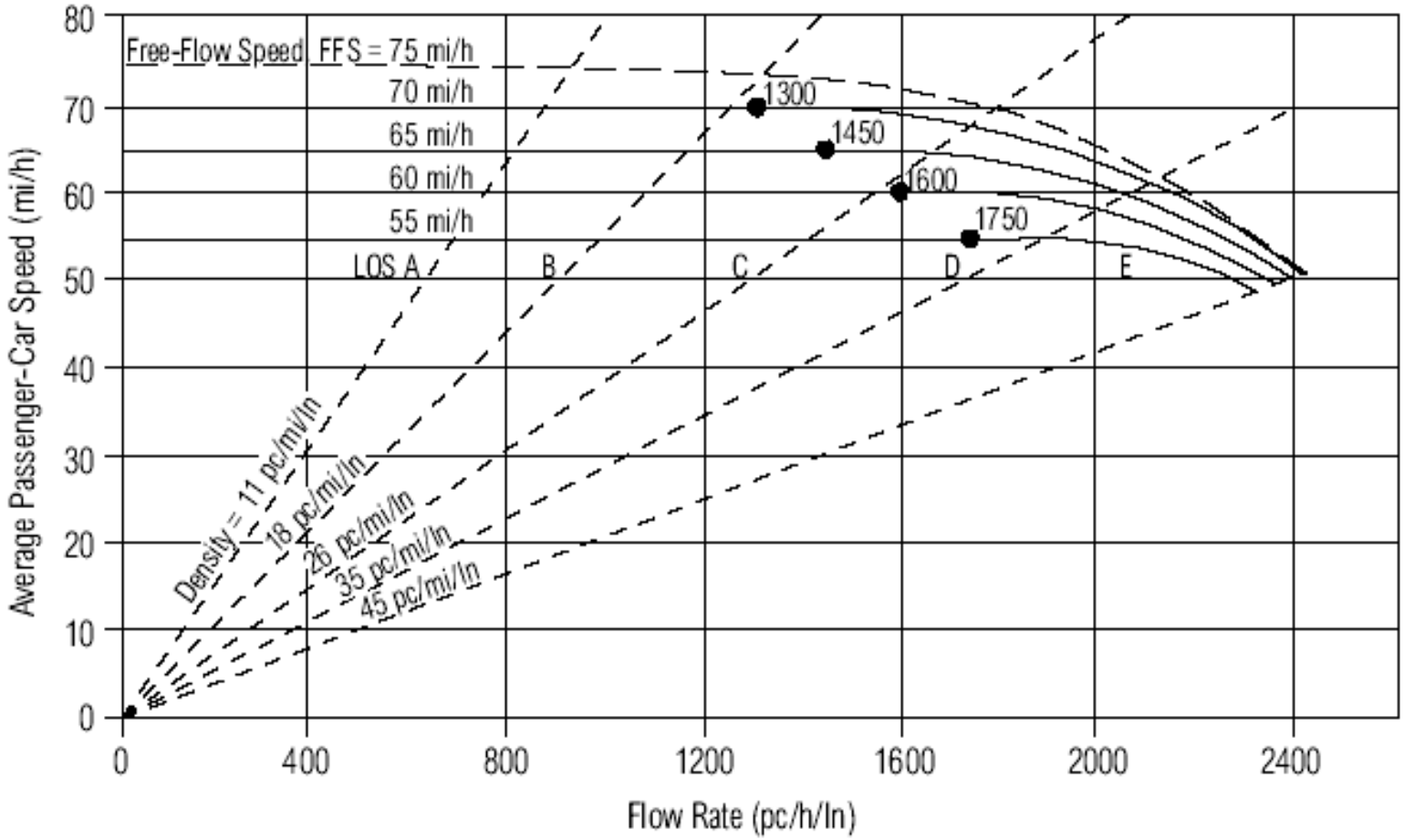

Figure 8: Speed Flow Curves

REFERENCE: HCM 2000

The LOS obtained for the present case scenario are depicted in the following table along with their densities obtained.

Section	Section location		NB Flow (veh/hr)				SB Flow (veh/hr)			
			Vp	Speed S	Density	LOS	Vp	Speed S	Density	LOS
1	T-CHOWK TO DHA		1111.53	52	21.38	C	1223.85	52	23.54	C
2	DHA TO KAHUTA RD		1312.25	52	25.24	C	1366.21	52	26.27	D
3	KAHUTA RD TO NAVAL ANCHORAGE		1749.94	52	33.65	D	1732.2606	52	33.31	D
4	NAVAL ANCHORAGE TO SOAN GARDENS	Before U-turn Soan Gardens	1878.58	52	36.13	E	1904.2657	52	36.62	E
		After U-turn Soan Gardens	2166.32	52	41.66	E	3307.8127	52	63.61	F
5	SOAN GARDENS TO PWD	Before U-turn of PWD	1837.67	52	35.34	E	2076.9987	52	39.94	E
		After U-turn of PWD	3577.49	52	68.80	F	2762.309	52	53.12	F
6	PWD TO GULBERG GREENS		2374.87	52	45.67	F	2417.02	52	46.48	F

Table 4: Current Scenario LOS

3.7 Route Zoning

The route was then zoned based upon the zoning guide presented at pg.11. The results of which are shown below.

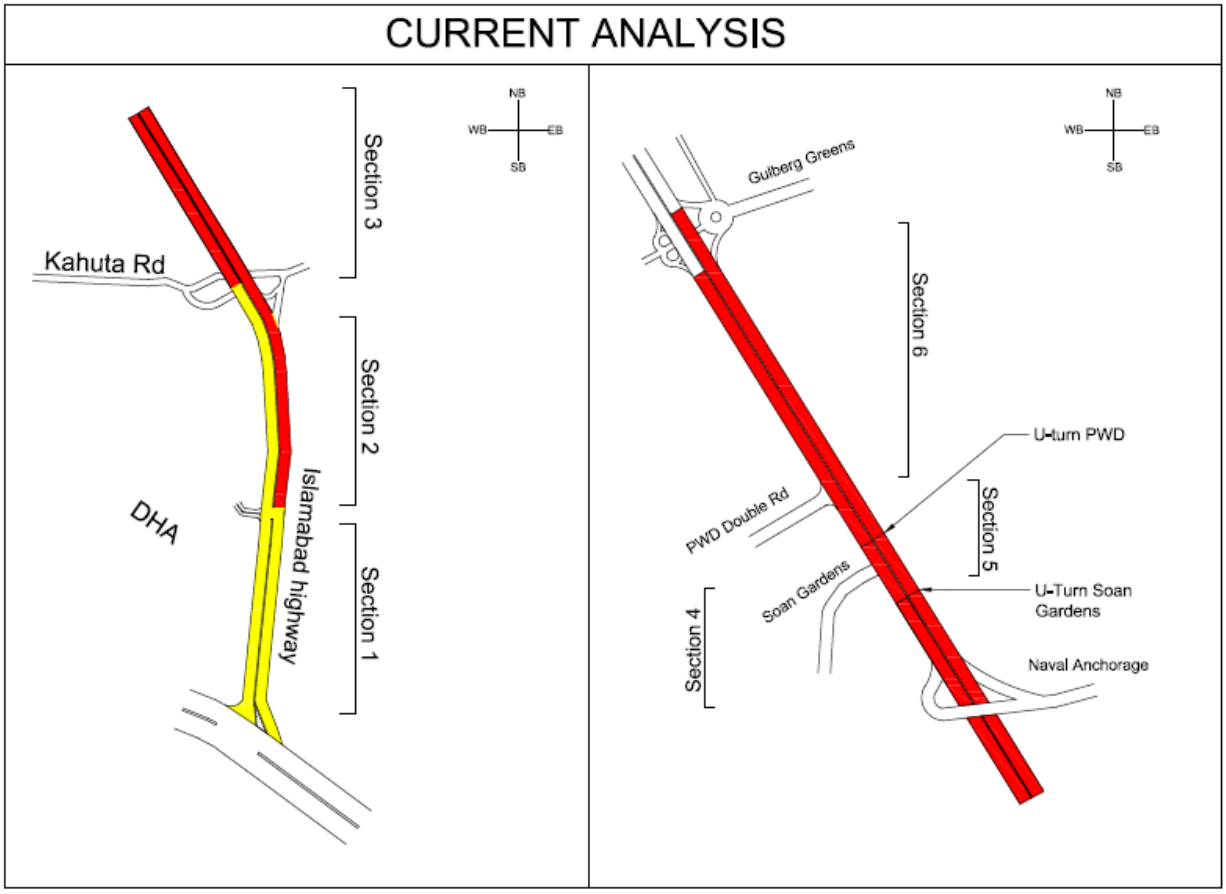

Figure 9: Zoning Based on LOS

From the route zoning the zones of high congestions can easily be deduced. The Highways are normally designed for LOS C and D but above that serious congestion occurs and hence a description of inadequate design.

3.8 Future Forecasting:

The highway design is never a yearly procedure but actually the analysis and design is based on some future forecasted demand. Typically roadways are designed for a time period of 20 years. Hence for the future forecasting a time period of 20 years was selected with a growth rate of 3%.

TABLE 6.13 Total Growth Factor

Design period (years)	Annual growth rate (%)							
	No growth	2	4	5	6	7	8	10
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	2.0	2.02	2.04	2.05	2.06	2.07	2.08	2.10
3	3.0	3.06	3.12	3.15	3.18	3.21	3.25	3.31
4	4.0	4.12	4.25	4.31	4.37	4.44	4.51	4.64
5	5.0	5.20	5.42	5.53	5.64	5.75	5.87	6.11
6	6.0	6.31	6.63	6.80	6.98	7.15	7.34	7.72
7	7.0	7.43	7.90	8.14	8.39	8.65	8.92	9.49
8	8.0	8.58	9.21	9.55	9.90	10.26	10.64	11.44
9	9.0	9.75	10.58	11.03	11.49	11.98	12.49	13.58
10	10.0	10.95	12.01	12.58	13.18	13.82	14.49	15.94
11	11.0	12.17	13.49	14.21	14.97	15.78	16.65	18.53
12	12.0	13.41	15.03	15.92	16.87	17.89	18.98	21.38
13	13.0	14.68	16.63	17.71	18.88	20.14	21.50	24.52
14	14.0	15.97	18.29	19.16	21.01	22.55	24.21	27.97
15	15.0	17.29	20.02	21.58	23.28	25.13	27.15	31.77
16	16.0	18.64	21.82	23.66	25.67	27.89	30.32	35.95
17	17.0	20.01	23.70	25.84	28.21	30.84	33.75	40.55
18	18.0	21.41	25.65	28.13	30.91	34.00	37.45	45.60
19	19.0	22.84	27.67	30.54	33.76	37.38	41.45	51.16
20	20.0	24.30	29.78	33.06	36.79	41.00	45.76	57.28
25	25.0	32.03	41.65	47.73	54.86	63.25	73.11	98.35
30	30.0	40.57	56.08	66.44	79.06	94.46	113.28	164.49
35	35.0	49.99	73.65	90.32	111.43	138.24	172.32	271.02

Source. After AI (1981a).

Table 5: Growth Factor

Reference: Pavement Analysis and Design
By Yang H. Huang
2nd Edition

The above table was used to determine the percentage increase in the traffic volume occupying the Islamabad Highway. By interpolation a value of 27.04% was obtained for total growth factor.

Based on the future forecasted values the following results were obtained which showed complete failure of the highway to satisfy the demand.

Section	Section location		NB Flow (veh/hr)				SB Flow (veh/hr)			
			Vp	Speed S	Density	LOS	Vp	Speed S	Density	LOS
1	T-CHOWK TO DHA		1411.51	52	27.14	D	1554.98	52	29.90	D
2	DHA TO KAHUTA RD		1666.91	52	32.06	D	1735.86	52	33.38	D
3	KAHUTA RD TO NAVAL ANCHORAGE		2222.97	52	42.75	E	2200.66	52	42.32	E
4	NAVAL ANCHORAGE TO SOAN GARDENS	Before U-turn Soan Gardens	2386.84	52	45.90	F	2419.18	52	46.52	F
		After U-turn Soan Gardens	2752	52	52.92	F	4201.7	52	80.80	F
5	SOAN GARDENS TO PWD	Before U-turn of PWD	2334.59	52	44.90	E	2638.27	52	50.74	F
		After U-turn of PWD	4545.2	52	87.41	F	3509.24	52	67.49	F
6	PWD TO GULBERG GREENS		3017.3	52	58.03	F	3070.58	52	59.05	F

Table 6: Future Forecasted LOS

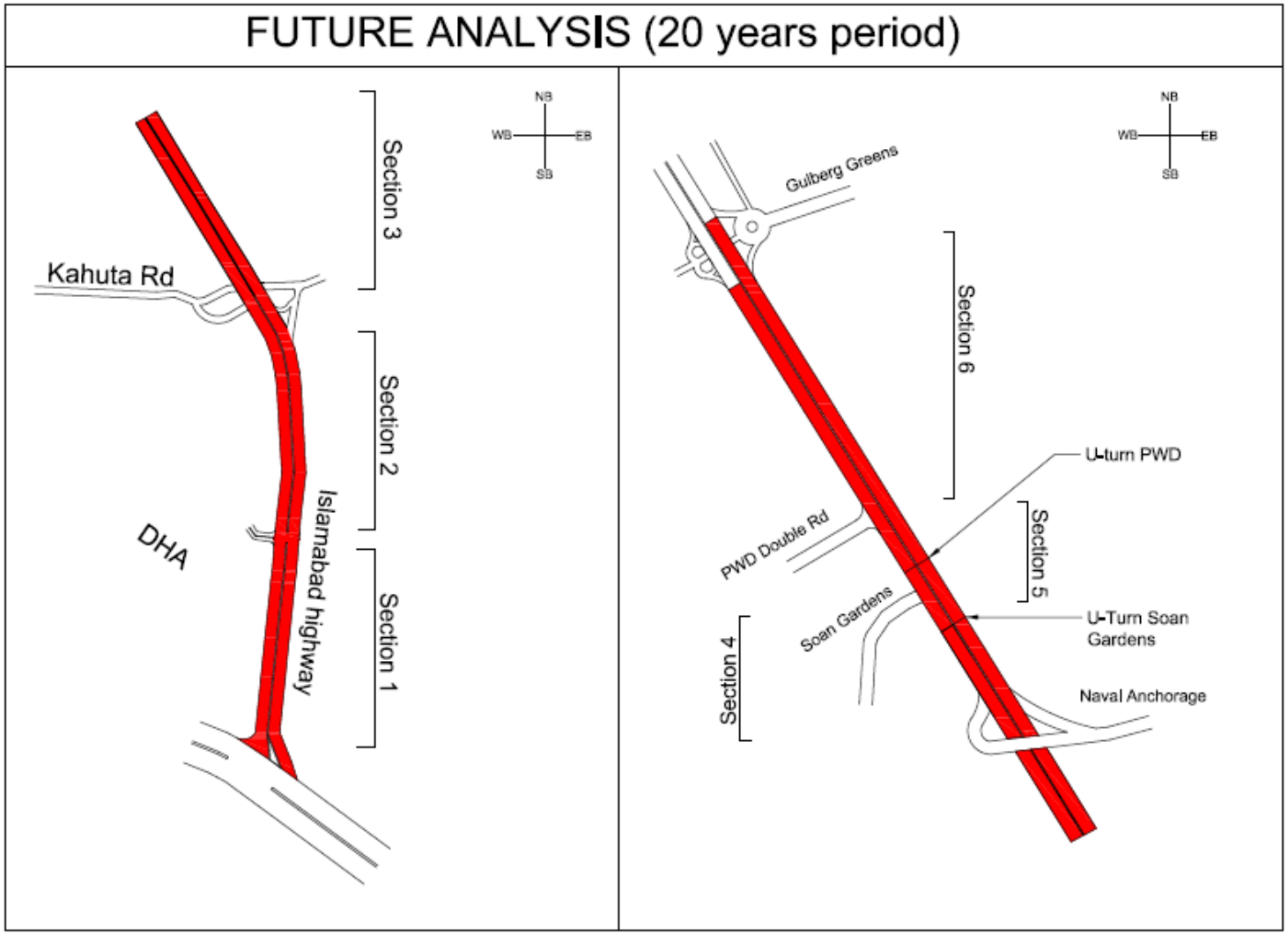

Table 7: Future Forecasted LOS Zoning

This shows the necessity of devising a strategy to address the deteriorating situation of the Islamabad Expressway.

3.9 Modelling in VISSIM:

The whole 11km span of Islamabad Expressway from Gulberg Greens to T-chowk was modelled on VISSIM. The procedural elements included

- Input traffic volume obtained from manual traffic counts.
- Assigning Priority movements at intersections.
- Assigning reduced speed zones near the intersection.

Nodal analysis was performed to calculate resultant delays at each intersection.

These delays were than compared to the following table to get the respective LOS.

Level of Service (LOS)	Signalized Intersection	Unsignalized Intersection
A	≤10 sec	≤10 sec
B	10-20 sec	10-15 sec
C	20-35 sec	15-25 sec
D	35-55 sec	25-35 sec
E	55-80 sec	35-50 sec
F	≥80 sec	≥50 sec

Table 8 Delay vs LOS

REFERENCE: HCM 2000

3.9.1 Current Analysis:

The current scenario of expressway was analyzed in VISSIM which yielded the following LOS at intersections. These LOS are for the delays estimated at each conflicting movements and hence are different from the manual calculations obtained for the highway.

Intersection	LOS
	Current Scenario
PWD	F
Soan Gardens	F
Naval Anchorage	A
Kahuta Rd	B
DHA	C

Table 9 VISSIM Results (Current Scenario)

Chapter 4

SOLUTION

After the preliminary analysis solutions are to be provided to solve the congestion problems on Islamabad Expressway. For this purpose, modeling is done on VISSIM to propose the alternate routes parallel to the Islamabad Expressway so that the traffic on Expressway is reduced.

Two solutions are proposed to address traffic congestion on Expressway.

1. Congestion Mitigation Plan
2. Frontage Road Plan

4.1 Congestion Mitigation Plan

The first plan was directly addressed towards solving the current congestion problems on Islamabad Expressway. The salient features are

- Providing an additional lane from Gulberg greens to Soan Gardens U-turn.
- An auxiliary lane is provided for both U-turns (PWD and Soan Garden)
- Signal is removed from PWD U-turn.
- Providing 24/7 movement to U-turns with no restrictions

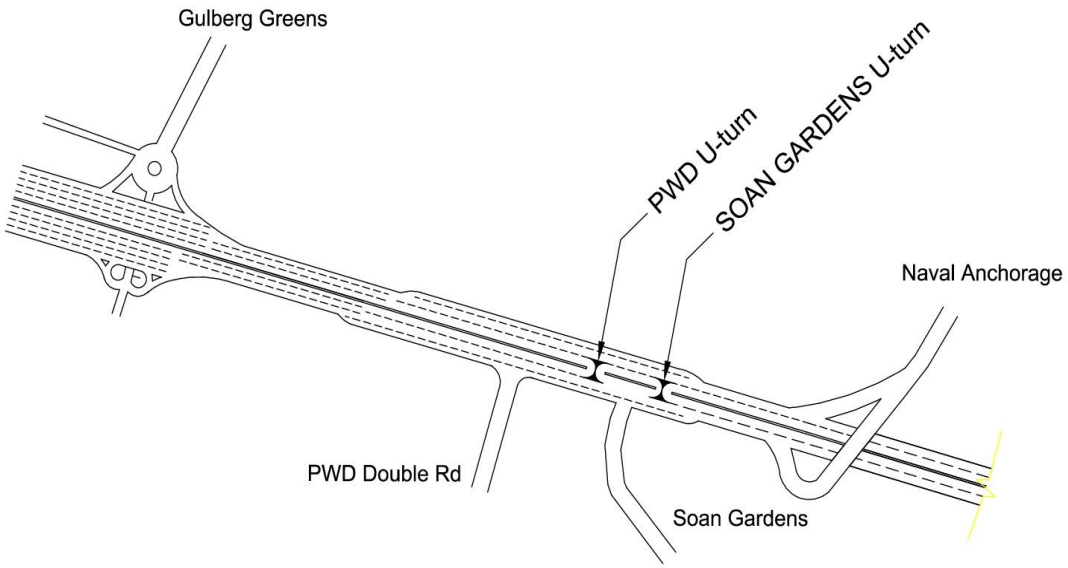

Figure 10 Congestion Mitigation Plan

4.1.1 Level of Service (from VISSIM):

The difference between level of service calculation from VISSIM and our manual calculation is that VISSIM actually calculates the LOS at intersections by solely determining the vehicular delay on the conflict points.

Except the DHA intersection, all rest of intersections had only merging and diverging conflicts. Hence the optimistic result for Kahuta Road and Naval Anchorage Intersection. The same was the case for PWD double road and Soan gardens but there major queues were present in front of these roads on Islamabad Expressway leading to deteriorated LOS.

Intersection	Scenario with Congestion mitigation	Future Scenario (after 20 years)
PWD	B	D
Soan Gardens	C	C
Naval Anchorage	A	B
Kahuta Rd	B	B
DHA	C	E

Table 10 Results with Congestion Mitigation Plan

4.1.2 Level of Service (Manual Calculation):

Since VISSIM only gives us LOS at intersections, Manual Calculation were performed to calculate the LOS at the Islamabad highway as well.

Section	Section location		Scenario with Congestion mitigation	
			NB Flow (veh/hr)	SB Flow (veh/hr)
1	T-CHOWK TO DHA		C	C
2	DHA TO KAHUTA RD		C	D
3	KAHUTA RD TO NAVAL ANCHORAGE		D	D
4	NAVAL ANCHORAGE TO SOAN GARDENS	Before U-turn Soan Gardens	C	C
		After U-turn Soan Gardens	D	E
5	SOAN GARDENS TO PWD	Before U-turn of PWD	C	D
		After U-turn of PWD	F	E
6	PWD TO GULBERG GREENS		F	F

Table 11: Manual Calculations with Congestion Mitigation Plan

The results obtained after applying the first plan were somewhat good with only two sections going into LOS E and F.

The same was forecasted for future demand of 20 years which still showed deteriorated service and hence needed to be reinforced with another parallel plan.

Section	Section location		Future Scenario (after 20 years)	
			NB Flow (veh/hr)	SB Flow (veh/hr)
1	T-CHOWK TO DHA		D	D
2	DHA TO KAHUTA RD		D	D
3	KAHUTA RD TO NAVAL ANCHORAGE		E	E
4	NAVAL ANCHORAGE TO SOAN GARDENS	Before U-turn Soan Gardens	D	D
		After U-turn Soan Gardens	E	F
5	SOAN GARDENS TO PWD	Before U-turn of PWD	D	D
		After U-turn of PWD	F	E
6	PWD TO GULBERG GREENS		F	F

Table 12: Future Forecasted LOS with Congestion Mitigation Plan

4.2 Frontage Road Plan:

Considering the level of service on highway for the previous plan, there is still a need of an extra road to divide the traffic load of Islamabad Expressway. This frontage road provides access to the housing societies, hence reducing the traffic from Islamabad Expressway since Alternate routes cannot be provided through housing societies and private properties.

The benefits of this plan are

- In case of vehicle breakdown or any accident, the traffic must be diverted to another route to avoid long queues.
- If we just focus on providing additional lanes, it will not serve during accidents or road blockages.

PROPOSED LAYOUT

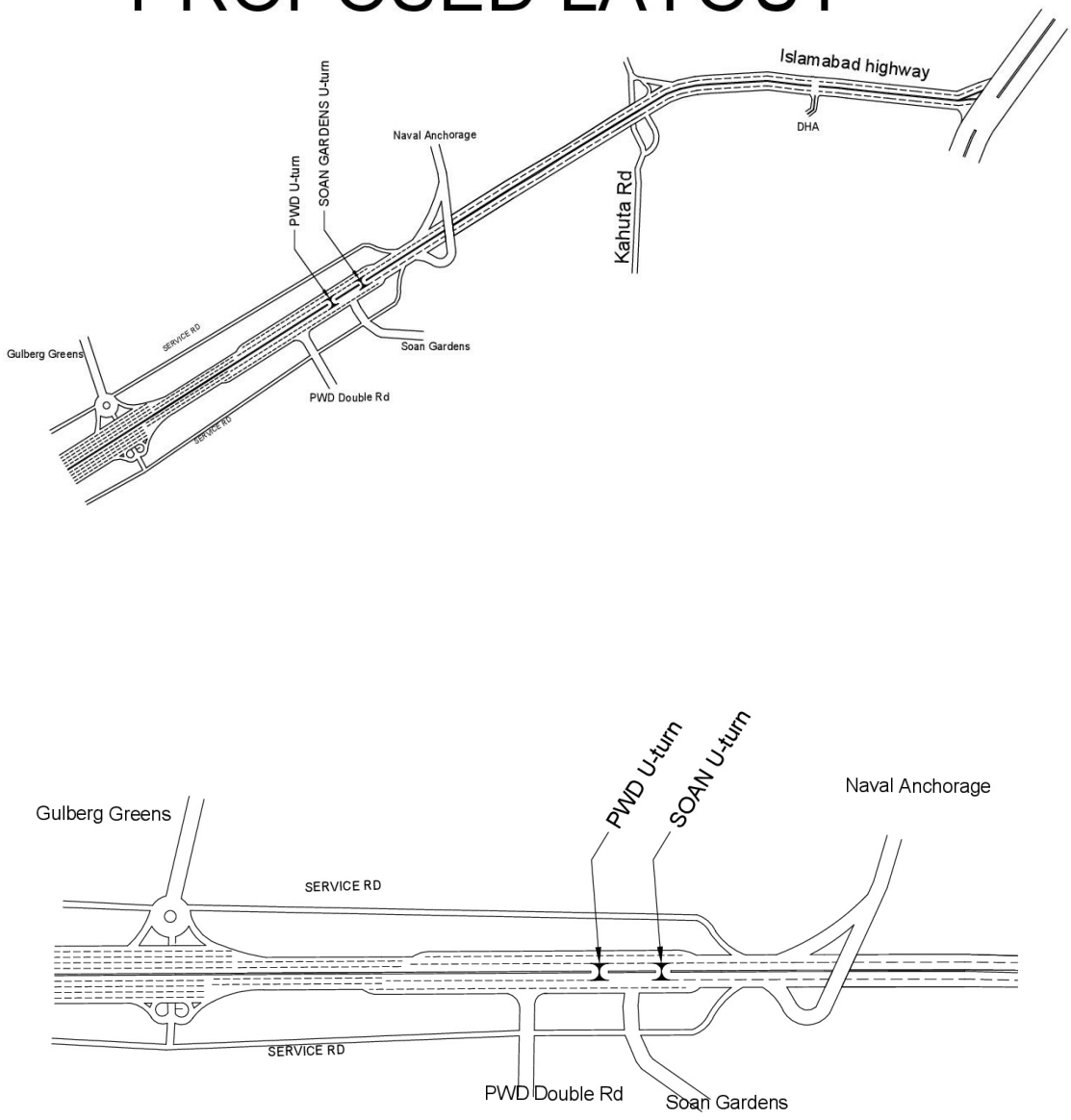

Figure 11: Frontage Road Plan proposed layout

4.2.1 Level of Service at Nodes (VISSIM):

After application of this plan the intersectional level of service from VISSIM's delay comparison method was calculated. The procedure yielded much better result at intersections for both current and future scenarios.

Intersection	Scenario with Service Road Plan	Future Scenario (after 20 years)
PWD	A	C
Soan Gardens	A	C
Naval Anchorage	A	A
Kahuta Rd	B	B
DHA	C	E
Service Rd PWD	D	E
Service Rd Soan Garden	A	A
Gulberg Greens	C	D

Table 13 VISSIM Results with Frontage Road Plan

4.2.2 Level of Service at Highway (Manual calculations):

Manual calculations were also performed to calculate level of service at highway after the application of the frontage road plan which showed sutability of both the plans towards reducing the congestion problem on the main Islamabad Highway.

Section	Section location		Scenario with Service Road Plan	
			NB Flow (veh/hr)	SB Flow (veh/hr)
1	T-CHOWK TO DHA		C	C
2	DHA TO KAHUTA RD		C	D
3	KAHUTA RD TO NAVAL ANCHORAGE		D	D
4	NAVAL ANCHORAGE TO SOAN GARDENS	Before U-turn Soan Gardens	C	B
		After U-turn Soan Gardens	C	C
5	SOAN GARDENS TO PWD	Before U-turn of PWD	C	B
		After U-turn of PWD	E	C
6	PWD TO GULBERG GREENS		C	C

Table 14 Manual Calculations with Frontage Road Plan

The future forecast was also satisfactory with only one of the section going into level of service F. Overall the plan was much efficient in addressing the congestion problems.

Section	Section location		Future Scenario (after 20 years)	
			NB Flow (veh/hr)	SB Flow (veh/hr)
1	T-CHOWK TO DHA		D	D
2	DHA TO KAHUTA RD		D	D
3	KAHUTA RD TO NAVAL ANCHORAGE		E	E
4	NAVAL ANCHORAGE TO SOAN GARDENS	Before U-turn Soan Gardens	C	B
		After U-turn Soan Gardens	D	D
5	SOAN GARDENS TO PWD	Before U-turn of PWD	C	C
		After U-turn of PWD	F	D
6	PWD TO GULBERG GREENS		D	D

Table 15 Future Forecasted LOS with Frontage Road Plan

Chapter 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

- Upstream diversion of vehicles can be provided in case of vehicular breakdown/accident etc. in case of frontage roads hence reducing traffic demand on main highway.
- Better real time traffic management and diversion control by introduction of ITS.
- More economical than increasing the highway capacity from 2 to 5 lanes.
- The SB frontage road would act as a bypass road for through traffic without any conflicts till development of the adjacent housing societies.
- Suitability of the presented plan in terms of level of service for current as well as future forecasted scenario.

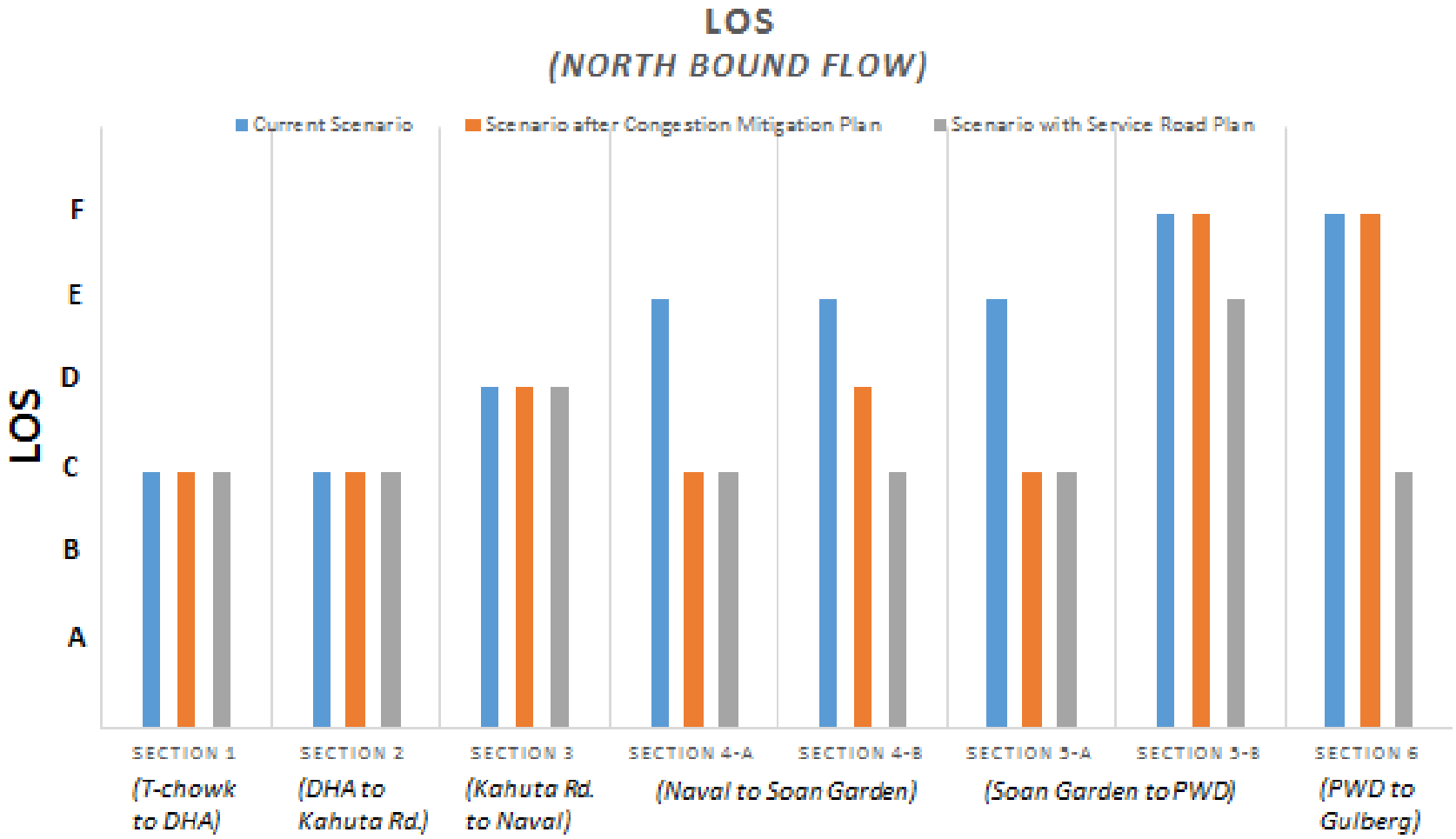

Figure 16 LOS Comparison (North Bound Flow)

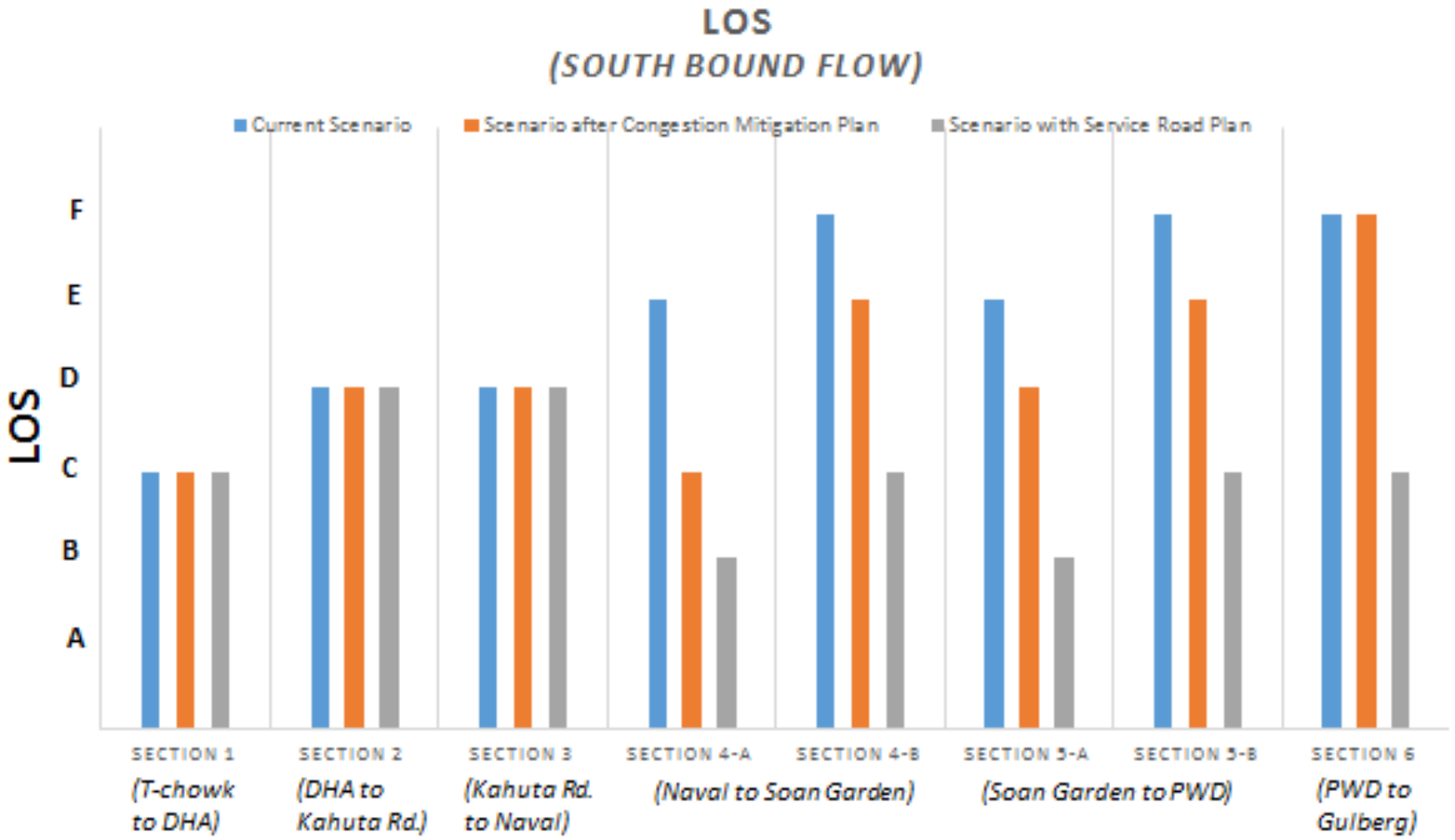

Figure 17 LOS Comparison (South Bound Flow)

5.2 Recommendation

5.2.1 ITS integration

- ITS stands for Intelligent Transport System.
- Use of ITS in this project is to ensure effective use of alternate routes
- Congestion/queuing is determined on the routes and the traffic is diverted to alternate routes automatically by using automated guide signs.
- The assignment of vehicles would be done based upon the balance of v/c ratio and the necessity would be determined by the queue analysis.

A simple module of Intelligent Transport System is also proposed as shown

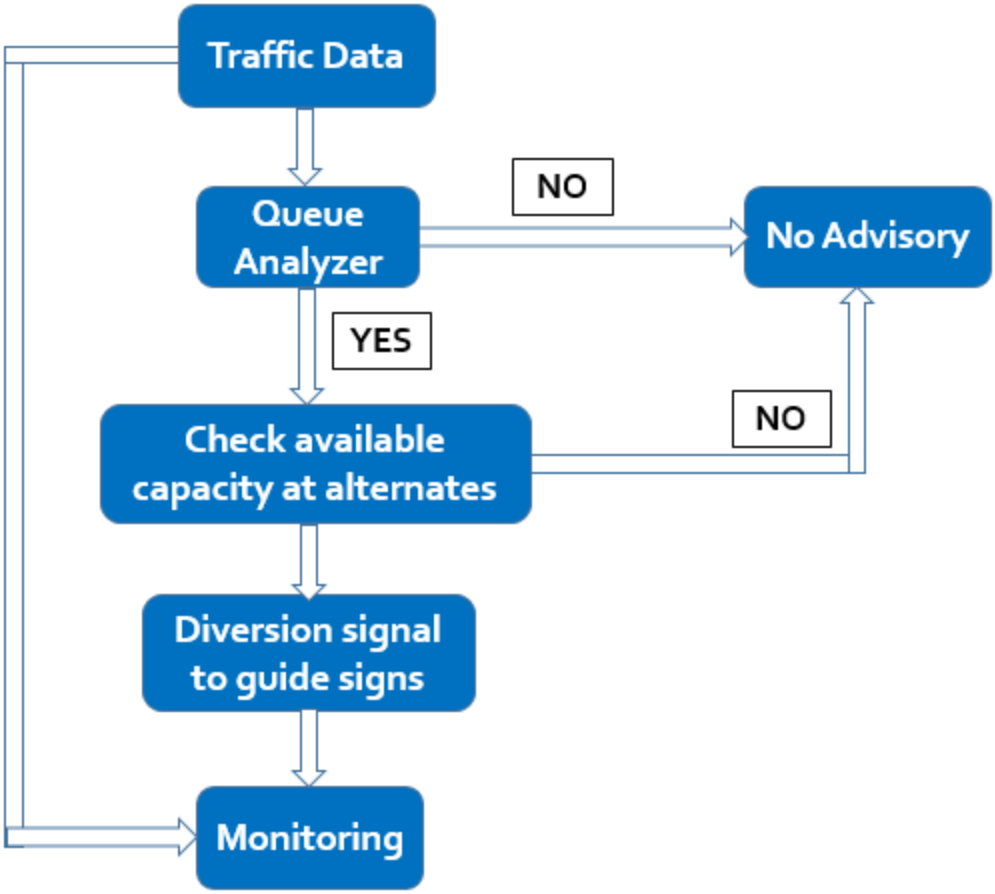

Figure 12 ITS Module

The functional procedure will be

- An Integrated system of detectors and guide signs would be used along the span of highway and the frontage roads.
- The detectors could be automated like queue detectors, speed detectors, accident detectors etc. or human operated video cams.
- The algorithms would be run based on the proposed module and the response sent to the guide signs preceding the detectors for diversion.
- In case of NB traffic the diverted traffic would comprise of PWD and Soan gardens while the SB traffic would totally comprise of through traffic.

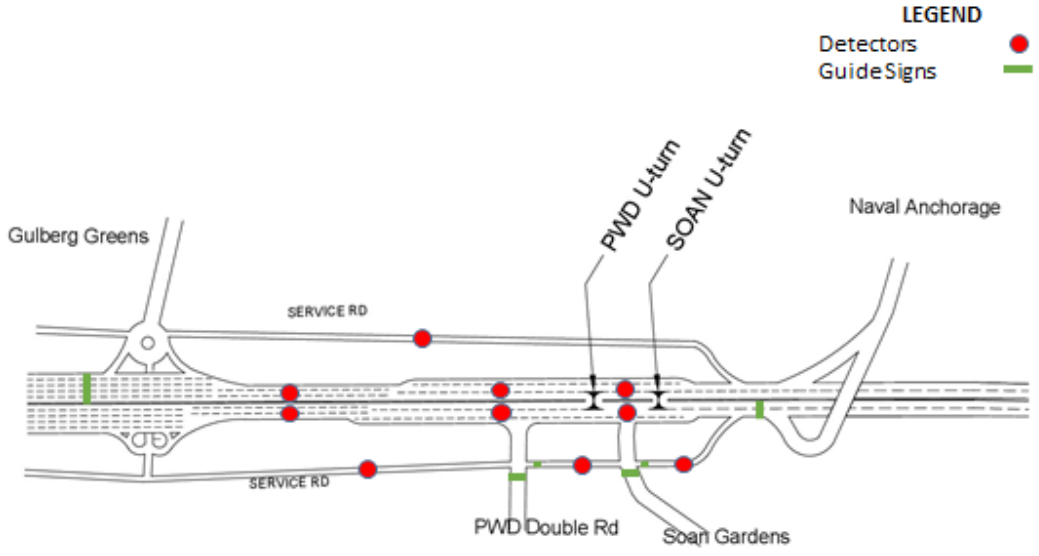

Figure 13 Integrated Plan for Detectors and Guide Signs

5.2.2 Rawalpindi Bypass

- Lesser no. of lanes and increased usage by heavy vehicular movement is aggravating the traffic problems on Islamabad Highway.
- Due to their lane occupancy long queues are generated behind these slow moving trucks.
- Rawalpindi Bypass can serve as an excellent alternate for heavy vehicles omitting their need for intra city trips.

SECTIONS	NB Flow (veh/hr)	SB Flow (veh/hr)
	% Total heavy vehicles	% Total heavy vehicles
1	11.20	12.22
2	9.87	10.47
3	10.40	11.98
4a	9.48	11.85
4b	8.52	9.79
5a	8.79	9.79
5b	6.57	7.03
6	8.03	7.03

Table 18 Heavy Vehicles Percentage

If Rawalpindi Bypass is successful in reducing the heavy vehicle percentage on the Islamabad Highway to 3-4% per section it would reduce the problems by an appreciable extent.

REFERENCES

- Wang, Y. and Zhang, C., 2013. ALTERNATIVE ROUTE STRATEGY FOR EMERGENCY TRAFFIC MANAGEMENT BASED ON ITS: A CASE STUDY OF XI'AN MING CITY WALL. Tehnicki vjesnik/Technical Gazette, 20(2).
- Triantis, K., Sarangi, S., Teodorović, D. and Razzolini, L., 2011. Traffic congestion mitigation: combining engineering and economic perspectives. Transportation Planning and Technology, 34(7), pp.637-645.
- Fesler, D.H., 2013. Evaluating traffic congestion mitigation strategies (Doctoral dissertation).
- Hobeika, A.G., Sivanandan, R., Subramaniam, S., Ozbay, K. and Zhang, Y., 1993. Real-time traffic diversion model: conceptual approach. Journal of transportation engineering, 119(4), pp.515-534.
- Khattak, A.J., Schofer, J.L. and Koppelman, F.S., 1993. Commuters' enroute diversion and return decisions: analysis and implications for advanced traveler information systems. Transportation Research Part A: Policy and Practice, 27(2), pp.101-111
- Calfee, J. and Winston, C., 1998. The value of automobile travel time: implications for congestion policy. Journal of Public Economics, 69(1), pp.83-102.
- Dechenaux, E., Mago, S.D. and Razzolini, L., 2014. Traffic congestion: an experimental study of the Downs-Thomson paradox. Experimental Economics, 17(3), pp.461-487
- Antoniou, C., Koutsopoulos, H.N., Ben-Akiva, M. and Chauhan, A.S., 2011. Evaluation of diversion strategies using dynamic traffic assignment. Transportation planning and technology, 34(3), pp.199-216.
- Arnott, R. and Small, K., 1994. The economics of traffic congestion. American scientist, 82(5), pp.446-455.

APPENDIX A

Vehicular Counts

DHA Phase 2 Gate# 7
South Bound Movement
Out from Highway (from left)
Morning Time

		Time interval								
Vehicle type	PCU's	7:00-7:15	7:15-7:30	7:30-7:45	7:45-8:00	8:00-8:15	8:15-8:30	8:30-8:45	8:45-9:00	9:00-9:15
Bike	0.5	7	11	9	15	15	23	28	28	27
Car	1	24	32	46	45	38	28	20	27	18
Hiace	2	1	2	1	0	1	0	0	1	0
Tractor without trailer	4.5	0	0	0	0	0	0	0	0	0
Tractor with trailer	4.5	0	0	0	0	0	0	0	0	0
Truck 2-3 axles	3	0	0	0	0	0	0	0	0	0
Truck 4-6 axles	3	0	0	0	0	0	0	0	0	0
Bus	3	0	0	0	0	0	0	0	0	0
TOTAL PCU's		29.5	41.5	52.5	52.5	47.5	39.5	34	43	31.5
Hourly volume					176	194	192	173.5	164	148
PHF						0.92				

BIKES	**50**
TOTAL	215

DHA Phase 2 Gate# 7
North Bound Movement
In to Highway (left)
Morning Time

Vehicle type	PCU's	7:00-7:15	7:15-7:30	7:30-7:45	7:45-8:00	8:00-8:15	8:15-8:30	8:30-8:45	8:45-9:00	9:00-9:15
Bike	0.5	8	4	13	17	12	18	16	8	7
Car	1	43	33	49	53	54	69	59	74	63
Hiace	2	1	2	3	0	2	0	1	2	1
Tractor without trailer	4.5	0	0	0	0	0	0	0	0	0
Tractor with trailer	4.5	0	0	0	0	0	0	0	0	0
Truck 2-3 axles	3	0	0	0	0	0	0	0	0	0
Truck 4-6 axles	3	0	0	0	0	0	0	0	0	0
Bus	3	0	0	0	0	0	0	0	0	0
TOTAL PCU's		49	39	61.5	61.5	64	78	69	82	68.5
Hourly volume					211	226	265	272.5	293	297.5
PHF						0.88				

BIKES	**46**
TOTAL	242

DHA Phase 2 Gate# 7
South Bound Movement
Out from Highway (from left)
Evening Time

		Time interval								
Vehicle type	PCU's	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5	11	20	12	15	13	11	11	4	3
Car	1	80	86	64	86	70	80	72	95	59
Hiace	2	3	0	4	0	2	1	6	0	0
Tractor without trailer	4.5	0	0	0	0	0	0	0	0	0
Tractor with trailer	4.5	0	0	0	0	0	0	0	0	0
Truck 2-3 axles	3	0	0	0	0	0	0	0	0	0
Truck 4-6 axles	3	0	0	0	0	0	0	0	0	0
Bus	3	0	0	0	0	0	0	0	0	0
TOTAL PCU's		91.5	96	78	93.5	80.5	87.5	89.5	97	60.5
Hourly volume					359	348	339.5	351	354.5	334.5
PHF						0.91				

BIKES	**60**
TOTAL	372

DHA Phase 2 Gate# 7
North Bound Movement
In to Highway (left)
Evening Time

		Time interval								
Vehicle type	PCU's	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5	47	51	54	52	50	22	28	21	15
Car	1	53	51	66	90	41	64	50	39	55
Hiace	2	0	0	0	0	0	0	0	0	0
Tractor without trailer	4.5	0	0	0	0	0	0	0	0	0
Tractor with trailer	4.5	0	0	0	0	0	0	0	0	0
Truck 2-3 axles	3	0	0	0	0	0	0	0	0	0
Truck 4-6 axles	3	0	0	0	0	0	0	0	0	0
Bus	3	0	0	0	0	0	0	0	0	0
TOTAL PCU's		76.5	76.5	93	116	66	75	64	49.5	62.5
Hourly volume					362	351.5	350	321	254.5	251
PHF						0.76				

BIKES	**207**
TOTAL	455

DHA Phase 2 Gate# 7
North Bound Movement
Out from Highway (from Right)
Morning Time

		Time interval								
Vehicle type	PCU's	7:00-7:15	7:15-7:30	7:30-7:45	7:45-8:00	8:00-8:15	8:15-8:30	8:30-8:45	8:45-9:00	9:00-9:15
Bike	0.5	7	12	8	17	20	22	30	27	27
Car	1	25	33	45	40	30	24	23	23	17
Hiace	2	1	1	2	1	2	1	0	2	1
Tractor without trailer	4.5	0	0	0	0	0	0	0	0	0
Tractor with trailer	4.5	0	0	0	0	0	0	0	0	0
Truck 2-3 axles	3	0	0	0	0	0	0	0	0	0
Truck 4-6 axles	3	0	0	0	0	0	0	0	0	0
Bus	3	0	0	1	0	0	0	0	0	0
TOTAL PCU's		30.5	41	56	50.5	44	37	38	40.5	32.5
Hourly volume					178	191.5	187.5	169.5	159.5	148
PHF						0.85				

BIKES	**57**
TOTAL	212

DHA Phase 2 Gate# 7
South Bound Movement
In to Highway (Right)
Morning Time

		Time interval								
Vehicle type	PCU's	7:00-7:15	7:15-7:30	7:30-7:45	7:45-8:00	8:00-8:15	8:15-8:30	8:30-8:45	8:45-9:00	9:00-9:15
Bike	0.5	7	17	9	11	8	6	13	12	18
Car	1	40	60	50	67	56	44	72	63	49
Hiace	2	2	1	3	0	1	0	2	1	2
Tractor without trailer	4.5	0	0	0	0	0	0	0	0	0
Tractor with trailer	4.5	0	0	0	0	0	0	0	0	0
Truck 2-3 axles	3	0	0	0	0	0	0	0	0	0
Truck 4-6 axles	3	0	0	0	0	0	0	0	0	0
Bus	3	0	0	0	0	0	0	0	0	0
TOTAL PCU's		29.5	41.5	52.5	52.5	47.5	39.5	34	43	31.5
Hourly volume					176	194	192	173.5	164	148
PHF						0.92				

BIKES	**45**
TOTAL	283

DHA Phase 2 Gate# 7
North Bound Movement
Out from Highway (from Right)
Evening Time

		Time interval								
Vehicle type	PCU's	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5	22	11	7	14	3	2	4	6	3
Car	1	41	30	14	36	20	10	20	40	30
Hiace	2	0	0	0	0	0	0	0	0	0
Tractor without trailer	4.5	0	0	0	0	0	0	0	0	0
Tractor with trailer	4.5	0	0	0	0	0	0	0	0	0
Truck 2-3 axles	3	0	0	0	0	0	0	0	0	0
Truck 4-6 axles	3	0	0	0	0	0	0	0	0	0
Bus	3	0	0	0	0	0	0	0	0	0
TOTAL PCU's		52	35.5	17.5	43	21.5	11	22	43	31.5
Hourly volume					148	117.5	93	97.5	97.5	107.5
PHF						0.68				

BIKES	**35**
TOTAL	135

DHA Phase 2 Gate# 7
South Bound Movement
In to Highway (Right)
Evening Time

		Time interval								
Vehicle type	PCU's	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5	6	4	3	7	5	1	3	3	4
Car	1	9	7	9	5	9	6	7	8	11
Hiace	2	0	0	0	0	0	0	0	0	0
Tractor without trailer	4.5	0	0	0	0	0	0	0	0	0
Tractor with trailer	4.5	0	0	0	0	0	0	0	0	0
Truck 2-3 axles	3	0	0	0	0	0	0	0	0	0
Truck 4-6 axles	3	0	0	0	0	0	0	0	0	0
Bus	3	0	0	0	0	0	0	0	0	0
TOTAL PCU's		12	9	10.5	8.5	11.5	6.5	8.5	9.5	13
Hourly volume					40	39.5	37	35	36	37.5
PHF						0.86				

BIKES	**19**
TOTAL	49

Kahuta Road
North Bound Movement (towards Islamabad)
Out from Highway
Evening Time

		Time interval								
Vehicle type	PCE	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5	20	32	29	33	27	28	18	28	24
Car	1	53	39	45	33	31	23	34	26	32
Hiace	2	10	7	6	9	5	9	7	13	11
Tractor without trailer	1.5	0	1	0	0	0	0	0	0	0
Tractor with trailer	4.5	4	1	2	3	1	0	1	0	0
Truck 2-3 axles	3	13	8	14	2	3	4	9	2	5
Truck 4-6 axles	4.5	3	1	5	1	0	1	2	0	2
Bus	3	16	5	7	0	0	1	3	2	6
Total PCU's		201.5	118.5	166	91.5	68	74.5	106.5	78	108
Hourly Volume					577.5	444	400	340.5	327	367
PHF						0.67				

Heavy veh	54
Trucks	42
Bikes	121
Buses	12
Total	350

Kahuta Road
North Bound Movement (towards Islamabad)
In to Highway
Evening Time

		Time interval								
Vehicle type	PCE	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5	82	72	69	64	42	39	34	22	27
Car	1	109	97	111	79	65	121	53	73	49
Hiace	2	18	22	19	32	29	26	17	16	13
Tractor without trailer	1.5	0	1	0	0	0	0	0	0	2
Tractor with trailer	4.5	3	2	5	4	3	2	4	1	6
Truck 2-3 axles	3	22	24	26	17	17	24	24	18	21
Truck 4-6 axles	4.5	2	3	3	1	0	1	3	2	5
Bus	3	16	13	7	4	4	3	2	5	9
Total PCU's		322.5	312	318.5	260.5	220.5	287	213.5	198.5	231
Hourly Volume					1213.5	1112	1087	981.5	919.5	930
PHF						0.87				

Heavy veh	134
Trucks	106
Bikes	247
Buses	28
Total	835

Kahuta Road
South Bound Movement (towards Rawat)
Out from Highway
Evening Time

		Time interval								
Vehicle type	PCE	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5	58	50	53	68	41	33	51	63	55
Car	1	72	56	63	77	54	41	52	69	61
Hiace	2	18	15	11	16	10	9	14	11	8
Tractor without trailer	1.5	1	0	0	0	0	2	0	0	1
Tractor with trailer	4.5	4	0	2	5	5	0	0	3	0
Truck 2-3 axles	3	13	21	19	14	12	10	13	9	11
Truck 4-6 axles	4.5	1	3	2	3	0	2	1	0	4
Bus	3	7	4	6	4	3	1	2	1	1
Total PCU's		221	199.5	204.5	233	162	120.5	155	166	160
Hourly Volume					858	799	720	670.5	603.5	601.5
PHF						0.86				

Heavy veh	103
Trucks	86
Bikes	212
Buses	17
Total	617

Kahuta Road
South Bound Movement (towards Rawat)
In to Highway
Evening Time

		Time interval								
Vehicle type	PCE	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5	28	42	33	25	21	19	20	17	14
Car	1	53	45	51	34	45	31	36	27	23
Hiace	2	2	2	3	6	10	6	2	4	5
Tractor without trailer	1.5	1	0	0	0	0	1	1	0	1
Tractor with trailer	4.5	2	0	0	2	2	4	0	1	0
Truck 2-3 axles	3	5	3	4	5	5	3	1	1	3
Truck 4-6 axles	4.5	1	2	4	0	3	0	2	1	3
Bus	3	2	0	1	1	0	0	1	0	2
Total PCU's		107	88	106.5	85.5	113	81	66.5	55.5	70
Hourly Volume					387	393	386	346	316	273
PHF						0.87				

Heavy veh	32
Trucks	30
Bikes	121
Buses	2
Total	349

Naval Anchorage
South Bound Movement (towards Rawat)
In to Highway
Evening Time

		Time interval								
Vehicle type	PCU's	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5		8	9	6	11				
Car	1		15	17	11	12				
Hiace	2		1	1	1	2				
Tractor without trailer	4.5									
Tractor with trailer	4.5				1	1				
Truck 2-3 axles	3		1	1						
Truck 4-6 axles	3									
Bus	3									
TOTAL PCU's		0	24	26.5	20.5	26	0	0	0	0
Hourly volume					71	97	73	46.5	26	0
PHF						0.92				

Heavy veh	4
Trucks	4
Bikes	34
Buses	0
Total	98

Naval Anchorage
North Bound Movement (towards Islamabad)
In to Highway
Evening Time

		Time interval								
Vehicle type	PCU's	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5		24	26	18	32				
Car	1		45	50	32	37				
Hiace	2		3	3	1	8				
Tractor without trailer	4.5									
Tractor with trailer	4.5					1				
Truck 2-3 axles	3									
Truck 4-6 axles	3									
Bus	3									
TOTAL PCU's		0	63	69	43	73.5	0	0	0	0
Hourly volume					175	248.5	185.5	116.5	73.5	0
PHF						0.85				

Heavy veh	1
Trucks	1
Bikes	100
Buses	0
Total	280

Naval Anchorage
South Bound Movement (towards Rawat)
Out from Highway
Evening Time

		Time interval								
Vehicle type	PCU's	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5		10	19	33	29				
Car	1		31	43	39	50				
Hiace	2		2	1	1	3				
Tractor without trailer	4.5									
Tractor with trailer	4.5									
Truck 2-3 axles	3									
Truck 4-6 axles	3									
Bus	3		1							
TOTAL PCU's		0	43	54.5	57.5	70.5	0	0	0	0
Hourly volume					155	225.5	182.5	128	70.5	0
PHF						0.80				

Heavy veh	1	
Trucks	0	-4
Bikes	91	57
Buses	1	1
Total	262	164

Naval Anchorage
North Bound Movement (towards Islamabad)
Out from Highway
Evening Time

		Time interval								
Vehicle type	PCU's	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5		3	7	11	9				
Car	1		10	15	13	16				
Hiace	2		1			1				
Tractor without trailer	4.5									
Tractor with trailer	4.5			1						
Truck 2-3 axles	3		1		1	1				
Truck 4-6 axles	3									
Bus	3									
TOTAL PCU's		0	16.5	23	21.5	25.5	0	0	0	0
Hourly volume					61	86.5	70	47	25.5	0
PHF						0.85				

Heavy veh	4	
Trucks	4	-3
Bikes	30	70
Buses	0	0
Total	90	190

PWD Double Road
North Bound Movement (towards Islamabad)
Out from Highway
Evening Time

		Time interval								
Vehicle type	PCE	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5		72	81	68	82				
Car	1		259	221	237	256				
Hiace	2		22	12	13	15				
Tractor without trailer	1.5									
Tractor with trailer	4.5									
Truck 2-3 axles	3		1							
Truck 4-6 axles	4.5									
Bus	3				1	1				
Total PCU's		0	342	285.5	300	330	0	0	0	0
Hourly Volume					927.5	1257.5	915.5	630	330	0
PHF						0.92				

Heavy veh	3
Trucks	1
Bikes	303
Buses	2
Total	1341

PWD Double Road
North Bound Movement (towards Islamabad)
In to Highway
Evening Time

		Time interval								
Vehicle type	PCE	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5		90	96	111	115				
Car	1		196	209	205	197				
Hiace	2		17	14	13	11				
Tractor without trailer	1.5									
Tractor with trailer	4.5				1					
Truck 2-3 axles	3		3	1	5	4				
Truck 4-6 axles	4.5									
Bus	3		3	1	1	1				
Total PCU's		0	293	291	309	291.5	0	0	0	0
Hourly Volume					893	1185	891.5	600.5	291.5	0
PHF						0.96				

Heavy veh	20
Trucks	14
Bikes	412
Buses	6
Total	1294

PWD U-Turn
Traffic from Islamabad
Evening Time

		Time interval								
Vehicle type	PCE	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5		26	35	22	19				
Car	1		285	312	256	217				
Hiace	2		13	10	10	10				
Tractor without trailer	1.5									
Tractor with trailer	4.5		1							
Truck 2-3 axles	3			4						
Truck 4-6 axles	4.5									
Bus	3			1		1				
Total PCU's		0	328.5	364.5	287	249.5	0	0	0	0
Hourly Volume					980	1229.5	901	536.5	249.5	0
PHF						0.84				

Heavy veh	7
Trucks	5
Bikes	102
Buses	2
Total	1222

PWD U-Turn
Traffic from T-chowk
Evening Time

		Time interval								
Vehicle type	PCE	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5		14	17	10	16				
Car	1		16	20	12	22				
Hiace	2		1	1	1					
Tractor without trailer	1.5									
Tractor with trailer	4.5			6	2					
Truck 2-3 axles	3		1	1						
Truck 4-6 axles	4.5									
Bus	3									
Total PCU's		0	28	60.5	28	30	0	0	0	0
Hourly Volume					116.5	146.5	118.5	58	30	0
PHF						0.61				

Heavy veh	10
Trucks	10
Bikes	57
Buses	0
Total	140

Soan Garden
North Bound Movement (towards Islamabad)
Out from Highway
Evening Time

		Time interval								
Vehicle type	PCE	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5		76	81	61	74				
Car	1		163	176	181	121				
Hiace	2		5	8	4	6				
Tractor without trailer	1.5									
Tractor with trailer	4.5		1	3	2	2				
Truck 2-3 axles	3		1	4	1	1				
Truck 4-6 axles	4.5									
Bus	3									
Total PCU's		0	218.5	258	231.5	182	0	0	0	0
Hourly Volume					708	890	671.5	413.5	182	0
PHF						0.86				

Heavy veh	15
Trucks	15
Bikes	292
Buses	0
Total	971

Soan Garden
North Bound Movement (towards Islamabad)
In to Highway
Evening Time

		Time interval								
Vehicle type	PCE	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5		59	64	51	78				
Car	1		85	82	94	96				
Hiace	2		4	7	5	1				
Tractor without trailer	1.5									
Tractor with trailer	4.5			1	1	2				
Truck 2-3 axles	3		2	1		3				
Truck 4-6 axles	4.5									
Bus	3									
Total PCU's		0	128.5	135.5	134	155	0	0	0	0
Hourly Volume					398	553	424.5	289	155	0
PHF						0.89				

Heavy veh	10	-5
Trucks	10	-5
Bikes	252	-40
Buses	0	0
Total	636	-335

T-chowk
North Bound Movement (G.T. road to Islamabad Highway)
Evening Time

		Time interval								
Vehicle type	**PCU**	**5:00-5:15**	**5:15-5:30**	**5:30-5:45**	**5:45-6:00**	**6:00-6:15**	**6:15-6:30**	**6:30-6:45**	**6:45-7:00**	7:00-7:15
Bike	0.5	63	67	75	73	69	59	73	61	44
Car	1	132	135	180	176	127	142	129	120	135
Hiace	2	39	42	37	54	44	44	44	43	39
Tractor without trailer	1.5	1	0	0	0	0	0	0	0	0
Tractor with trailer	4.5	0	1	0	1	4	1	4	0	3
Truck 2-3 axles	3	39	41	38	39	27	34	38	37	34
Truck 4-6 axles	4.5	1	5	6	3	4	4	0	2	1
Bus	3	3	4	8	6	7	9	4	8	3
TOTAL PCU's		373.5	414.5	456.5	473.5	387.5	411	397.5	380.5	364
Hourly Volume					1718	1732	1728.5	1669.5	1576.5	1553
PHF						0.91				

T-chowk
North Bound Movement (Islamabad Highway to G.T. Road)
Evening Time

Vehicle type	PCU	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5	89	102	112	103	78	66	72	73	65
Car	1	163	183	181	137	149	166	162	158	149
Light Commercial vehicle	2	33	37	40	36	32	39	51	39	33
Tractor without trailer	1.5	1	0	0	0	2	0	0	0	0
Tractor with trailer	4.5	0	0	0	5	1	0	0	0	1
Truck 2-3 axles	3	28	46	60	30	26	37	31	29	32
Truck 4-6 axles	4.5	5	7	1	4	3	6	5	2	7
Bus	3	9	14	5	5	16	16	7	5	5
TOTAL PCU's		408.5	519.5	516.5	406	399	463	436.5	383.5	394.5
Hourly Volume					1851	1841	1785	1705	1682	1678
PHF						0.89				

Soan Garden U-Turn
Traffic from Islamabad
Evening Time

		Time interval								
Vehicle type	PCE	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5		55	60	57	19				
Car	1		96	114	100	45				
Hiace	2		4	1	2					
Tractor without trailer	1.5			1						
Tractor with trailer	4.5				2	1				
Truck 2-3 axles	3		2		2	1				
Truck 4-6 axles	4.5									
Bus	3		1							
Total PCU's		0	140.5	147.5	147.5	62	0	0	0	0
Hourly Volume					435.5	497.5	357	209.5	62	0
PHF						0.84				

Soan Garden U-Turn
Traffic from T-Chowk
Evening Time

		Time interval								
Vehicle type	PCE	5:00-5:15	5:15-5:30	5:30-5:45	5:45-6:00	6:00-6:15	6:15-6:30	6:30-6:45	6:45-7:00	7:00-7:15
Bike	0.5			1						
Car	1		2	2	2	6				
Hiace	2									
Tractor without trailer	1.5									
Tractor with trailer	4.5		1	5	1	3				
Truck 2-3 axles	3		1	1		1				
Truck 4-6 axles	4.5									
Bus	3									
Total PCU's		0	9.5	28	6.5	22.5	0	0	0	0
Hourly Volume					44	66.5	57	29	22.5	0
PHF						0.59				