

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)  
DIRECTORATE GENERAL OF ROADS  
MINISTRY OF COMMUNICATIONS  
THE SULTANATE OF OMAN

THE DETAILED DESIGN STUDY  
ON  
ROAD DEVELOPMENT PROJECT

FINAL REPORT  
APPENDICES

MARCH 1997

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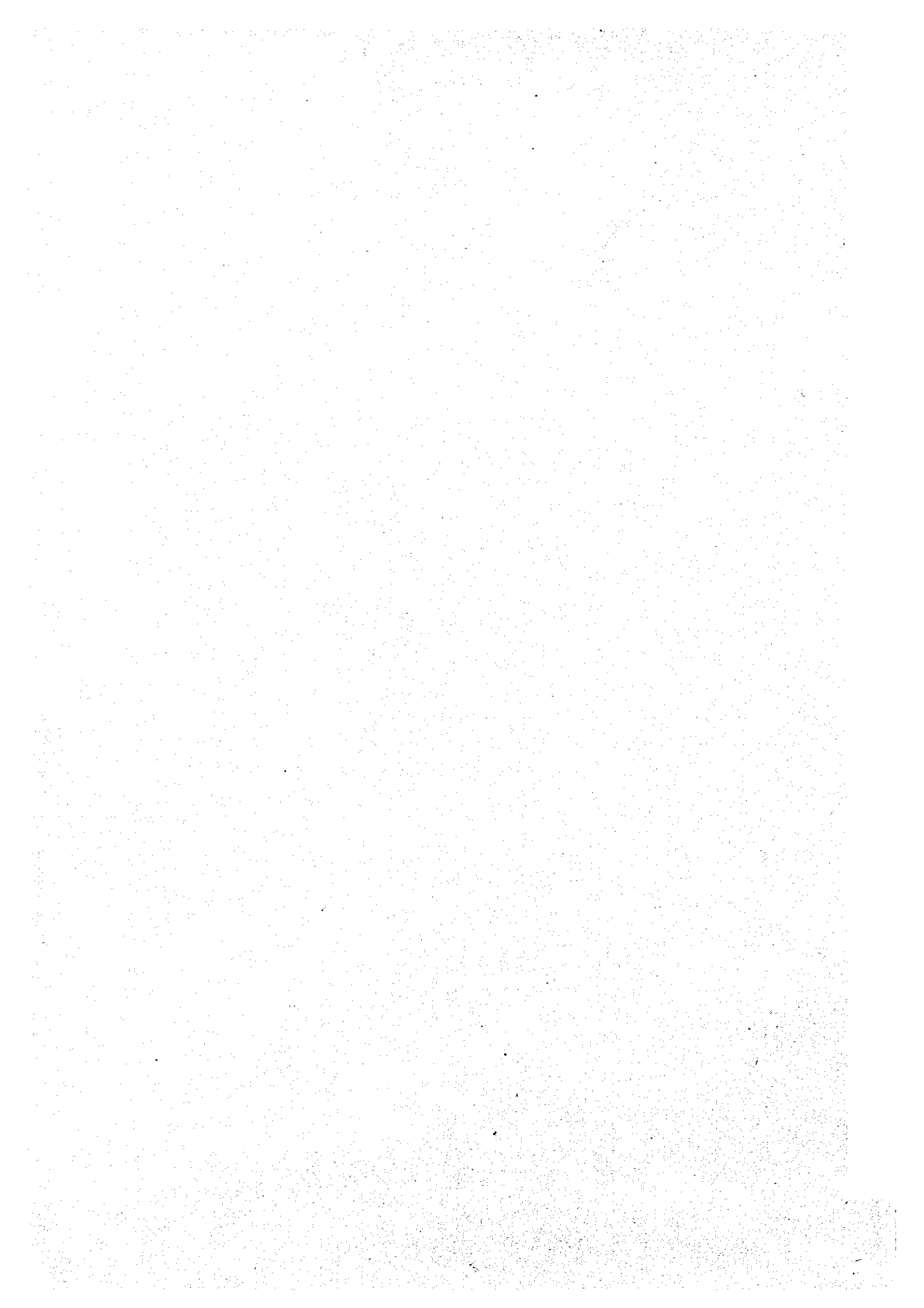
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**APPENDIX I**  
**SUPPLEMENTARY TRAFFIC SURVEY**  
**AND DATA**





## Appendices I SUPPLEMENTARY TRAFFIC SURVEYS

### I.1 Objectives of Traffic Survey

The objectives of carrying out the supplementary traffic surveys are:

- (1) To evaluate and measure the rates of traffic volume increase on the Batinah Highway since 1994, hence providing the basis for reviewing the forecasted future traffic demand by the year 2010 in the Feasibility Study,
- (2) To count the volume of pedestrians crossing the highway at recommended locations for the pedestrian underpasses, hence enabling the ranking of the proposed twelve underpasses.

### I.2 Scope and Methods of Traffic Surveys

#### I.2.1 Scope of Traffic Survey

Two basic types of traffic surveys were carried out in January 1996. These were,

Table I. 1. Scope of Traffic Surveys

No.	Type of Survey	Location	Period of Survey	Classifications/ Categories	Date
1.	Classified Vehicle Turning Movement Survey	1. A Nascem Garden R/A 2. Barka R/A 3. Al Mulladah Junction 4. Al Khaburah R/A 5. Saham R/A 6. Sohar R/A 7. Falaj Al Qabail R/A 8. Aqr R/A	24 hours 24 hours 12 hours 12 hours 12 hours 12 hours 12 hours 12 hours	5 vehicle types: 1. car/taxi/van, 2. pickup/ light truck, 3. med.truck 4. hvy.truck 5. bus	6.1.96 (sat) to 10.1.96 (wed)
2.	Pedestrian Volume Survey and Classified Traffic Volume Count Survey	1. Barka 2. Al Billah 3. A Tareef 4. Al Qarat 5. A Tharmad 6. A Suweiq 7. Al Khadra 8. Qarih 9. Majaz A Sughra 10. Khor A Siyabi 11. Liwa 12. Asrar Bani Sa'd	12 hours 12 hours 12 hours 12 hours 12 hours 12 hours 12 hours 12 hours 12 hours 12 hours 12 hours 12 hours	3 categories: Adults, Children, Student  ----- 5 veh.types as in 1 above	2.1.96 (tues)  to 10.1.96 (wed)

The traffic turning movement survey at the eight recommended roundabouts for the construction of flyovers would provide more accurate turning movement traffic volume for 24 or 12 hours period. Traffic classification in these surveys is the same as in the F/S study.

The pedestrian counting survey was carried out at the proposed twelve underpass locations. Counting was done by direction and divided into 3 categories of adults, children and students. The survey was carried out for 12 hours for all locations. In addition, classified traffic count (similar 5 vehicle types) by direction was conducted simultaneously at these locations.

### 1.2.2 Survey Methods

Due to the size of the roundabouts, 12 directional counts are needed at each location to ascertain all the traffic streams. (See Figure I. 1) 12 traffic survey enumerators are therefore required for each survey location. Pre-prepared survey forms were used to record the hourly observed volumes by vehicle types. Traffic counters were used for the Car/Van/Taxi category along the main line and within the roundabouts.

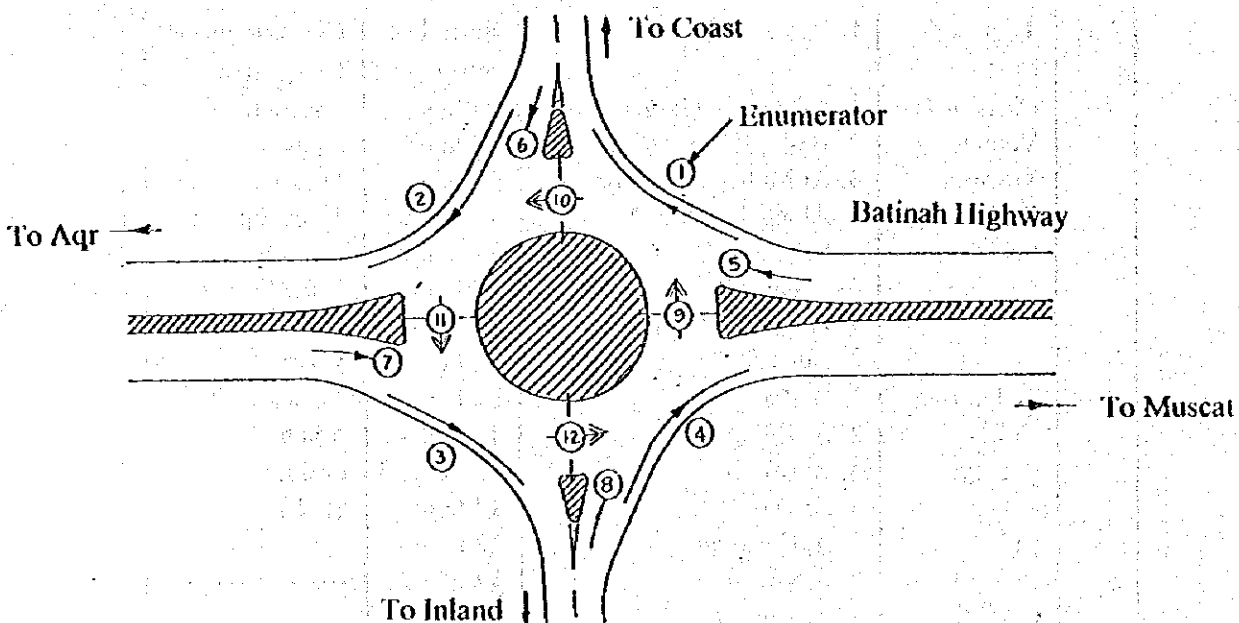


Figure I. 1: 12-Directional Counts By Vehicle Type at Roundabout

At the end of the survey, traffic volumes by vehicle type by direction were computed. The right turn traffic volumes are obtained directly from the counts V1, V2, V3 and V4. Left turn traffic however, has to be computed by simple arithmetic using the directional counts within the roundabout. The left turn traffic from Muscat for instance, is then obtained by  $(V11 - V6 + V2)$ . Similarly, the left turn traffic from Aqr will be equal to  $(V9 - V8 + V4)$ . The through traffic from Muscat is computed by subtracting the left turn and right turn traffic from the total (V5).

For pedestrian counting survey, the enumerators are stationed in the median and pedestrians crossing the highway within a section of about 100 m are counted as shown in Figure I. 2.

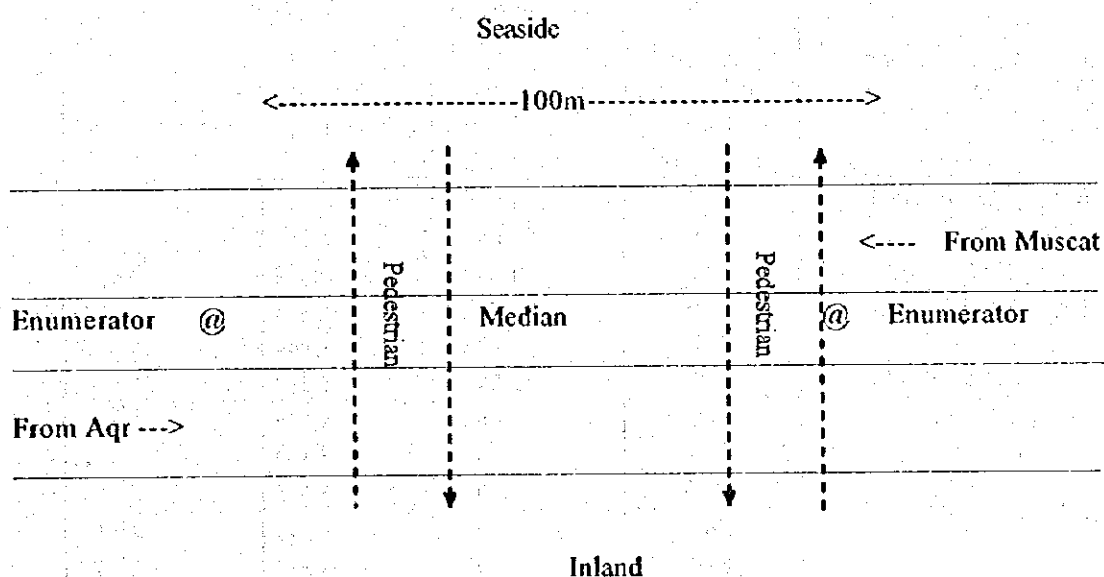


Figure I. 2: Pedestrian Traffic Counting Within a Sight Distance of 100m

### I.3 Results of Traffic Survey

#### I.3.1 Classified Traffic Turning Movement Survey

The classified traffic turning movement survey conducted in this study provided the three following major pieces of information.

##### (1) Total Traffic Volume by Direction

The total traffic volume by direction at each location is summarized in Table I. 2.

The general traffic volume pattern has not changed from 1994. In describing the traffic volume along Batinah Highway, allowances must be made for day-of-the-week variations and seasonal variations. This is because of the nature of traffic on this regional highway

where there is a high proportion of through long-distance traffic. Traffic volume along the Batinah Highway generally declines from Naseem Garden R/A towards Aqr R/A, but with slight increases near Sohar R/A. This can be seen in Figure I. 3.

The 24-hour traffic volumes at A Naseem Garden R/A are about 21,000 veh/day and at Barka R/A about 15,500 veh/day

**Table I. 2: Results of Traffic Volume Survey**

No.	Name of R/A	Direction	From Muscat	From Aqr	From Coast	From Inland
R/A-2	A'Naseem Garden (24 Hours Count)	Entry	11,350	9,855	1,286	493
		Exit	9,861	10,872	660	1,591
		Total 2-Dir.	21,211	20,727	1,946	2,084
R/A-3	Barka (24 Hours count)	Entry	7,525	7,953	3,832	3,897
		Exit	8,046	6,369	4,336	4,456
		Total 2 Dir.	15,571	14,322	8,168	8,353
R/A-5	Al Muladdah (12 Hours Count)	Entry	5,608	4,285	-	2,659
		Exit	4,919	5,197	-	2,436
		Total 2 Dir	10,527	9,482	-	5,095
R/A-8	Al Khaburah (12 Hours Count)	Entry	3,821	4,393	3,001	1,916
		Exit	3,388	3,944	2,935	2,864
		Total 2 Dir	7,209	8,337	5,936	4,780
R/A-10	Saham (12 Hours Count)	Entry	4,046	3,355	3,585	3,743
		Exit	3,995	4,160	3,331	3,243
		Total 2 Dir	8,041	7,515	6,916	6,986
R/A-12	Sohar (12 Hours Count)	Entry	2,850	5,341	8,952	2,215
		Exit	3,971	3,827	5,931	5,629
		Total 2 Dir	6,821	9,168	14,883	7,844
R/A-14	Falaj Al Qabail (12 Hours Count)	Entry	3,752	2,898	1,268	2,019
		Exit	3,626	3,553	912	1,846
		Total 2 Dir.	7,378	6,451	2,180	3,865
R/A-18	Aqr (12 Hours Count)	Entry	1,846	1,095	146	1,402
		Exit	1,925	955	200	1,409
		Total 2 Dir	3,771	2,050	346	2,811

Note: 12 hours means 6 am to 6 pm.

The 12-hour traffic volumes at Muladdah Junction are about 10,000 veh/day, about 8,000 veh/day at Khaburah R/A and Saham R/A, 9,000 veh/day at Sohar R/A, 7,400 veh/day at Falaj Al Qabail R/A and 3,700 veh/day at Aqr R/A.

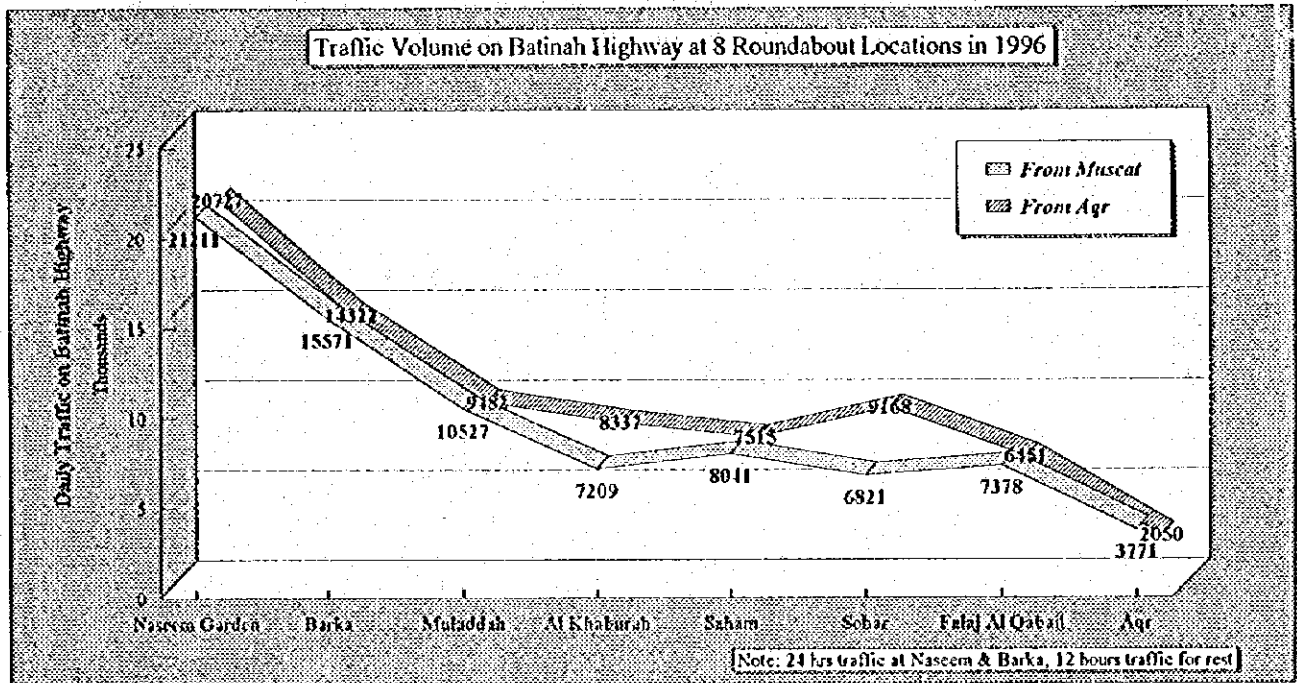


Figure I. 3. Traffic Volume on Batinah Highway in 1996

(2) Traffic Composition

At the eight surveyed roundabouts, the traffic on Batinah Highway consisted of an average 64% of passenger cars/vans, 30% pickup and small trucks, 2.7% medium trucks, 2.9% heavy truck and only 0.4% buses. Variations along the highway can be seen in Figure I. 4. Pickups increase between Al Khaburah and Falaj Al Qabail R/As.

Heavy vehicle traffic is heaviest at 5.6% near Falaj Al Qabail R/A and medium truck at 7% near Saham R/A. However, the proportion of medium trucks at the time of survey is influenced by the on-going pavement rehabilitation project on Batinah Highway.

Traffic composition on the cross roads is also similar to the pattern shown on Batinah Highway, although the share of pickups tend to be slightly higher while passenger cars share is lower.

**(3) Traffic Turning Movement**

Except for Aqr R/A, through traffic constitutes the major proportion of traffic at all the study roundabouts in both directions. Table I. 3 shows the results of the turning movement survey at the 8 locations. More than 90% of the traffic at A' Naseem Garden R/A are through traffic. At the other roundabouts, through traffic constitutes an average of 62%. Share of through traffic at Sohar R/A however is slightly lower at about 35%

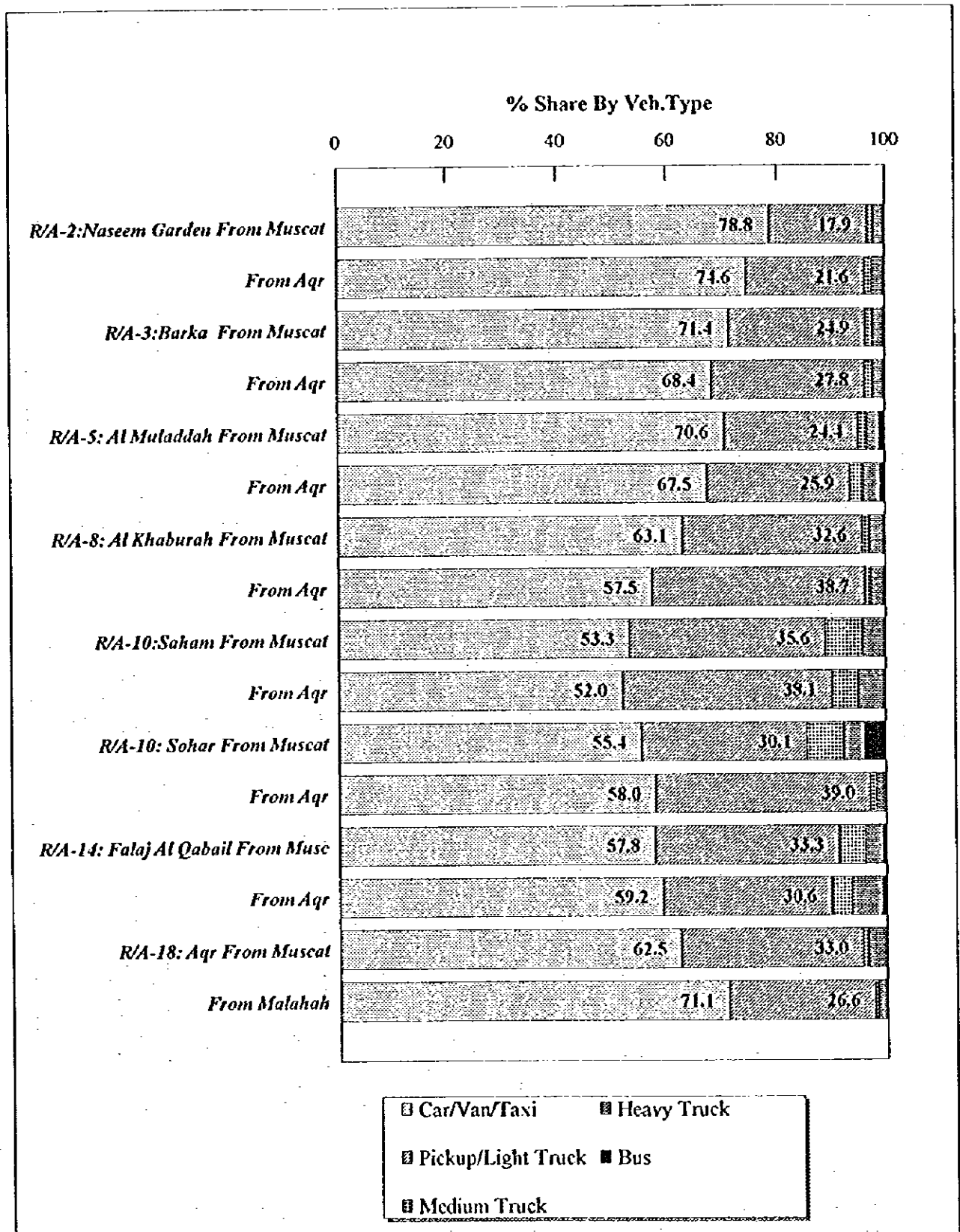


Figure I. 4: Traffic Composition on Batinah Highway at 8 Study Roundabouts

**Table I. 3. Traffic Turning Movement at Roundabouts From Batinah Highway**

No.	Name of R/A	Direction	Left Turn	Through	Right Turn
R/A-2	A' Naseem Garden	From Muscat	8.9%	89.8%	1.3%
		From Aqr	3.5%	95.6%	0.9%
R/A-3	Barka	From Muscat	32.8%	61.6%	5.6%
		From Aqr	19.4%	76.0%	4.6%
R/A-5	Al Muladdah Junction	From Muscat	31.9%	68.1%	-
		From Aqr	-	84.9%	15.1%
R/A-8	Al Khaburah	From Muscat	30.3%	55.8%	13.9%
		From Aqr	33.9%	58.0%	8.2%
R/A-10	Saham	From Muscat	21.1%	63.0%	15.9%
		From Aqr	17.7%	64.9%	17.4%
R/A-12	Sohar	From Muscat	12.6%	43.5%	43.8%
		From Aqr	68.0%	26.5%	5.5%
R/A-14	Falaj Al Qabail	From Muscat	30.4%	65.9%	3.7%
		From Aqr	14.6%	74.1%	11.2%
R/A-18	Aqr	From Muscat	62.9%	34.1%	3.0%
		From Aqr	8.6%	72.0%	19.4%

**Table I. 4. Traffic Turning Movement at Roundabouts from Cross Roads**

No.	Name of R/A	Direction	Left Turn	Through	Right Turn
R/A-2	A' Naseem Garden	From Coast	21.0%	38.0%	41.0%
		From Inland	31.5%	34.1%	34.5%
R/A-3	Barka	From Coast	35.2%	42.2%	22.5%
		From Inland	22.4%	60.8%	16.8%
R/A-5	Al Muladdah Junction	From Coast	-	-	-
		From Inland	51.8%	-	48.2%
R/A-8	Al Khaburah	From Coast	19.8%	44.9%	35.3%
		From Inland	39.3%	47.8%	12.8%
R/A-10	Saham	From Coast	34.8%	50.4%	14.8%
		From Inland	28.8%	55.9%	15.2%
R/A-12	Sohar	From Coast	27.5%	55.6%	16.9%
		From Inland	48.4%	47.4%	4.2%
R/A-14	Falaj Al Qabail	From Coast	58.0%	29.8%	12.1%
		From Inland	46.0%	17.3%	36.8%
R/A-18	Aqr	From Coast	14.5%	23.9%	61.6%
		From Inland	16.8%	3.7%	79.6%

Left-turning traffic from the direction of Muscat towards inland is significant at several locations, especially at Aqr R/A (63%) and about 30% at Falaj Al Qabail R/A, Barka, Al Muladdah and Khaburah R/As. Right turning traffic from the direction of Muscat to the coast is significant at Sohar Roundabout (43.8%)



From the opposite direction of Aqr, left-turning traffic to the coast is significant at Sohar R/A (68%) and Al Khaburah R/A (33.9%). Right turning traffic to the inland is less than 20%.

Table I. 4 shows the turning movements of traffic coming from the coast and inland areas. Through traffic is great at Barka R/A (42.2% and 60.8%), Sohar R/A (55.6% and 47.4%), Saham R/A (50.4% and 55.9%), Al Khaburah R/A (44.9% and 47.8%). From the inland areas, right turn traffic towards Muscat constitutes 79.6% at Aqr Roundabout. This indicates that local traffic is significant at these locations.

#### (4) Hourly Distribution of Traffic

There are considerable variations in the hourly distribution of traffic demand pattern at the eight roundabouts. This phenomenon has also been recognized in the previous Feasibility Study. The results of traffic study this time also reaffirmed this trend.

Roundabouts nearer to Muscat, such as Naseem Garden and Barka, display more distinct peak hour pattern while those away from Muscat have more evenly distributed traffic throughout the day. The former group of locations thus conforms to a pattern that is often seen in urban areas, while those in the second group conform to a pattern that is typical of rural highways.

What this analysis means is that peak traffic volume ratios would differ between these basic two group of roundabouts. For those with more distinct peaks, the peak traffic volume ratios would be higher than those with more evenly distribution pattern. Table I. 5 shows the surveyed peak traffic volume ratios at the roundabout computed using the expanded 24 hour traffic volumes.

Table I. 5. Peak Hour Traffic Ratios at Roundabouts

Roundabout	Muscat Approach	Aqr Approach	Coastal Approach	Inland Approach
R/A-2:Nasem Garden	10.7%	10.9%	11.3%	10.0%
R/A-3:Barka	9.1%	9.2%	8.9%	8.5%
R/A-5:Muladdah	7.6%	8.1%	-	8.0%
R/A-8:Al Khaburah	6.5%	7.2%	8.0%	9.3%
R/A-10:Saham	7.1%	7.8%	8.3%	9.0%
R/A-12:Sohar	7.6%	7.1%	6.6%	7.0%
R/A-14:Falaj Al Qabail	6.9%	6.6%	8.9%	6.7%
R/A-18:Aqr	8.2%	8.1%	10.6%	7.7%

The ratios on the Batinah Highway at Naseem Garden and Barka are higher than those in the other locations. On the whole, an average ratio of about 8% is the result of the finding. For the computation of traffic capacity requirement on highway and other facilities to be planned, an average peak hour traffic ratio of 8% was used in the Feasibility Study. For this Detailed Design Study, the same ratio of 8% will be used as, based on the results of the survey presented in the above table.

**(5) Expanded Daily Traffic Volume at Roundabouts**

Traffic volumes at 6 locations from Muladdah to Aqr roundabouts are surveyed for 12 hours only. For further analyses, these volumes are expanded to 24 hours traffic. The expansion factors used are obtained from the previous Feasibility Study where 24 hours traffic counts by classification were conducted for Muladdah junction, Al Khaburah R/A, Falaj Al Qabail R/A and Aqr R/A. For Sohar and Saham R/As, the same average expansion factors as used in the F/S for these two locations are applied in this study. Table I. 6 shows the expanded daily traffic volumes by approach at the roundabouts.

**Table I. 6: Expanded Daily Traffic Volumes at Roundabouts**

No.	Name of R/A	Direction	From Muscat	From Aqr	From Coast	From Inland
R/A-2	A Naseem Garden (24 Hours Count)	Entry	11,350	9,855	1,286	493
		Exit	9,861	10,872	660	1,591
		Total 2-Dir.	21,211	20,727	1,946	2,084
R/A-3	Barka (24 Hours count)	Entry	7,525	7,953	3,832	3,897
		Exit	8,046	6,369	4,336	4,456
		Total 2 Dir.	15,571	14,322	8,168	8,353
R/A-5	Al Muladdah (12 Hours Count)	Entry	8,291	6,645	-	3,643
		Exit	7,352	7,305	-	3,639
		Total 2 Dir	15,643	13,950	-	7,282
R/A-8	Al Khaburah (12 Hours Count)	Entry	5,724	6,913	4,375	2,670
		Exit	5,454	5,658	4,409	3,981
		Total 2 Dir	11,178	12,571	8,784	6,651
R/A-10	Saham (12 Hours Count)	Entry	6,070	5,201	5,126	5,202
		Exit	6,312	5,948	5,164	4,508
		Total 2 Dir	12,382	11,149	10,290	9,710
R/A-12	Sohar (12 Hours Count)	Entry	4,415	8,332	15,666	3,699
		Exit	6,151	5,970	10,379	9,288
		Total 2 Dir	10,566	14,302	26,045	12,987
R/A-14	Falaj Al Qabail (12 Hours Count)	Entry	5,837	4,578	2,127	3,281
		Exit	5,620	5,355	1,540	3,169
		Total 2 Dir.	11,457	9,933	3,667	6,450
R/A-18	Aqr (12 Hours Count)	Entry	2,934	1,739	237	2,179
		Exit	2,857	1,464	376	2,463
		Total 2 Dir	5,791	3,203	613	4,642

Note: volumes of R/A-5 to R/A-18 expanded from 12 hours counts .

### I.3.2 Pedestrian Traffic Survey

The pedestrian traffic counting survey provided the following results in revealing the volume and characteristics of the pedestrian traffic at the 12 proposed underpass locations:

#### (1) Pedestrian Traffic Volume

The highest pedestrian traffic volume is counted at P/U-1: Barka with a total 2 direction volume of 2,600 persons for 12 hours. At peak hour, the pedestrian volume exceeds 250 persons or about 4 persons every minute in both directions. The other locations with pedestrian volumes above 2,000 person/12 hours are P/U-3: A Tareef and P/U-6: A Suweiq.

The next group of underpass locations with pedestrian volumes more than 1,000 persons for 12 hours are at P/U-5: A Tharmad and P/U-7: Al Khadra. Table I. 7 shows the pedestrian volumes at the 12 locations by category. Figure I. 5 shows the pedestrian traffic volumes at the 12 locations in a descending order. The lowest volume being 431 persons at Khor A'Siyabi.

Table I. 7. Pedestrian Traffic Volumes at 12 Underpass Locations

No.	Location	Total Two Directions				Total 2-dir Traffic Volume
		Adult	Children	Student	Total	
P/U-1	Barka	2,299	74	230	2,605	11,289
P/U-2	Al Billah	536	31	205	772	8,850
P/U-3	A' Tareef	2,195	62	88	2,345	9,590
P/U-4	Al Qarat	389	42	28	459	9,124
P/U-5	A' Tharmad	959	41	68	1,133	9,647
P/U-6	A' Suweiq	1,456	46	572	2,074	8,215
P/U-7	Al Khadra	619	56	435	1,110	7,229
P/U-8	Qarih	387	44	162	593	6,987
P/U-9	Majaz A' Sughra	401	118	245	764	7,999
P/U-10	Khor A' Siyabi	200	2	229	431	8,701
P/U-11	Liwa	471	36	24	531	4,581
P/U-12	Asrar Bani Sa' d	449	63	65	577	4,214

Note: 12 hours counts for both traffic and pedestrians

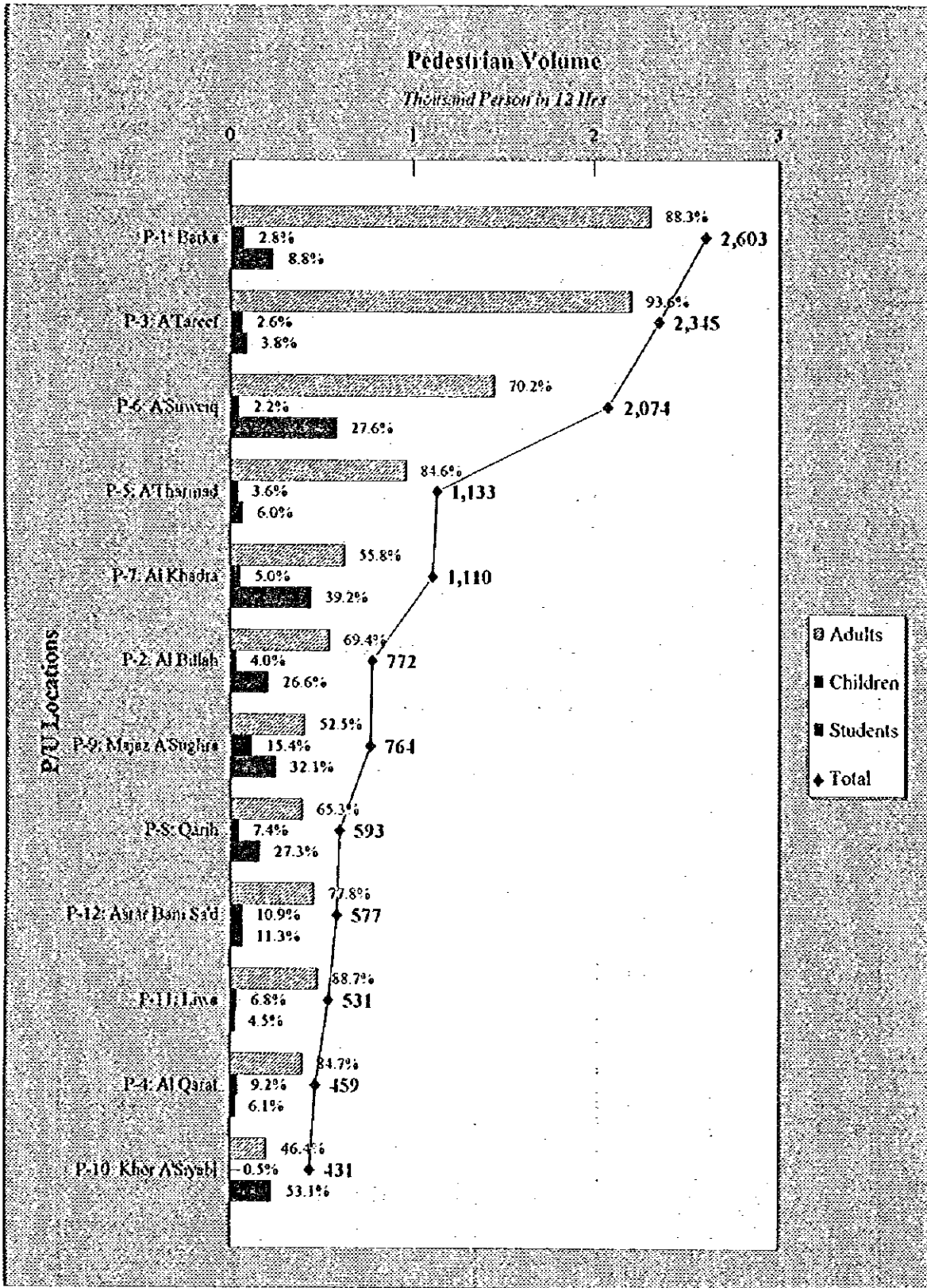


Figure I. 5. Pedestrian Traffic Volume in Decending Order At the 12 Locations

Most of the pedestrians surveyed are adults. At Majaz A Sughra, however, there are many small children cross the highway. At locations where there are schools, significant number of students are observed to cross the highway. Student volumes are comparatively higher at P/U-6: A' Suweiq, P/U-7: Al Khadra, P/U-9: Majaz A' Sughra, P/U-10: Khor A Siyabi and P/U-1: Barka.

The traffic volumes at these locations are also counted. The highest traffic volume is counted at P/U-1: Barka with a 12 hour 2 direction volume of 11,289 vehicles. Traffic volumes are about 9,000 vehicles at P/U-3, 4 and 5.

Locations with high pedestrian traffic volumes also correspond to locations with higher traffic volumes.

### **I.3.3 Traffic Growth On Batinah Highway Since 1994**

#### **(1) Traffic Volumes on Batinah Highway**

Traffic increases do vary along the highway and among the cross roads. Nevertheless, traffic volume on the Batinah Highway is found to increase on an average of about 6.0%-7.5% a year since 1994. Traffic volume increases are higher near Falaj Al Qabail R/A and Al Khaburah R/A, but lower at Sohar R/A, Barka R/A, Aqr R/A. Table I. 8 shows the comparative analyses of traffic volumes at the eight roundabout locations.

The negative growth of traffic in the comparison for the outbound at Barka R/A is most likely due to the variation of traffic demand between different days of the week. Generally, there is a higher traffic volume on the Batinah Highway on Wednesday, especially in the afternoon just before the weekend.

This average rate of traffic demand increase on the Batinah Highway is comparable to the future traffic demand increase rate of 7.2% used in the forecasting procedure in the Feasibility Study.

Figure I. 6 compares the general traffic increase trend on Batinah Highway between 1994 and 1996. Except for a slightly higher increase at Falaj Al Qabail R/A, and a fall at Sohar R/A, the traffic volume on Batinah Highway shows a general gradual increase at all the locations over the last two years.

Table I. 8: Average Annual Traffic Growth Rates on Batinah Highway at 8 R/A Locations

No.	Name of R/A	Year	Inbound Total Daily Traffic	Outbound Total Daily Traffic	Total 2-Dir. On Batinah Hwy	Remarks
R-2	A'Naseem Gar. (24 Hours)	1996	9,861	11,350	21,211	Wed
		1994	8,172	10,011	18,183	Wed
		Change	1,689	1,339	3,028	
		Ave.A.G.R %	9.8%	6.5%	8.0%	
R-3	Barka (24 Hours)	1996	8,046	7,525	15,571	Tues
		1994*	7,609	9,665	17,274	Wed
		Change	437	(2,140)	(1,703)	
		Ave.A.G.R %	2.8%	-11.8%	-5.1%	
R-5	Al Mulladah (12 Hours)	1996	4,919	5,608	10,527	Mon
		1994	4,509	4,575	9,084	Tues
		Change	410	1,033	1,443	
		Ave.A.G.R %	4.4%	10.7%	7.6%	
R-8	Al Khaburah (12 Hours)	1996	3,388	3,821	7,209	Mon
		1994	2,848	3,064	5,912	Mon
		Change	540	757	1,297	
		Ave.A.G.R %	9.1%	11.7%	10.4%	
R-10	Saham (12 Hours)	1996	3,995	4,046	8,041	Sun
		1994	3,401	3,531	6,932	Tues
		Change	594	515	1,109	
		Ave.A.G.R %	8.4%	7.0%	7.7%	
R-12	Sohar (12 Hours)	1996	3,971	2,850	6,821	Sun
		1994	4,324	2,946	7,270	Sun
		Change	(353)	(96)	(449)	
		Ave.A.G.R %	-4.2%	-1.6%	-3.1%	
R-14	Falaj Al Qabail (12 Hours)	1996	3,626	3,752	7,378	Sat
		1994	2,642	2,642	5,284	Sun
		Change	984	1,110	2,094	
		Ave.A.G.R %	17.2%	19.2%	18.2%	
R-18	Aqr (12 Hours)	1996	1,925	1,846	3,771	Sat
		1994	1,835	1,671	3,506	Sat
		Change	90	175	265	
		Ave.A.G.R %	2.4%	5.1%	3.7%	
Average of all 8 locations			6.2%	5.8%	5.9%	
Average without Barka			6.7%	8.4%	7.5%	

Notes: All traffic on Batinah On approach towards Muscat

\* Expanded from 12 hours traffic data

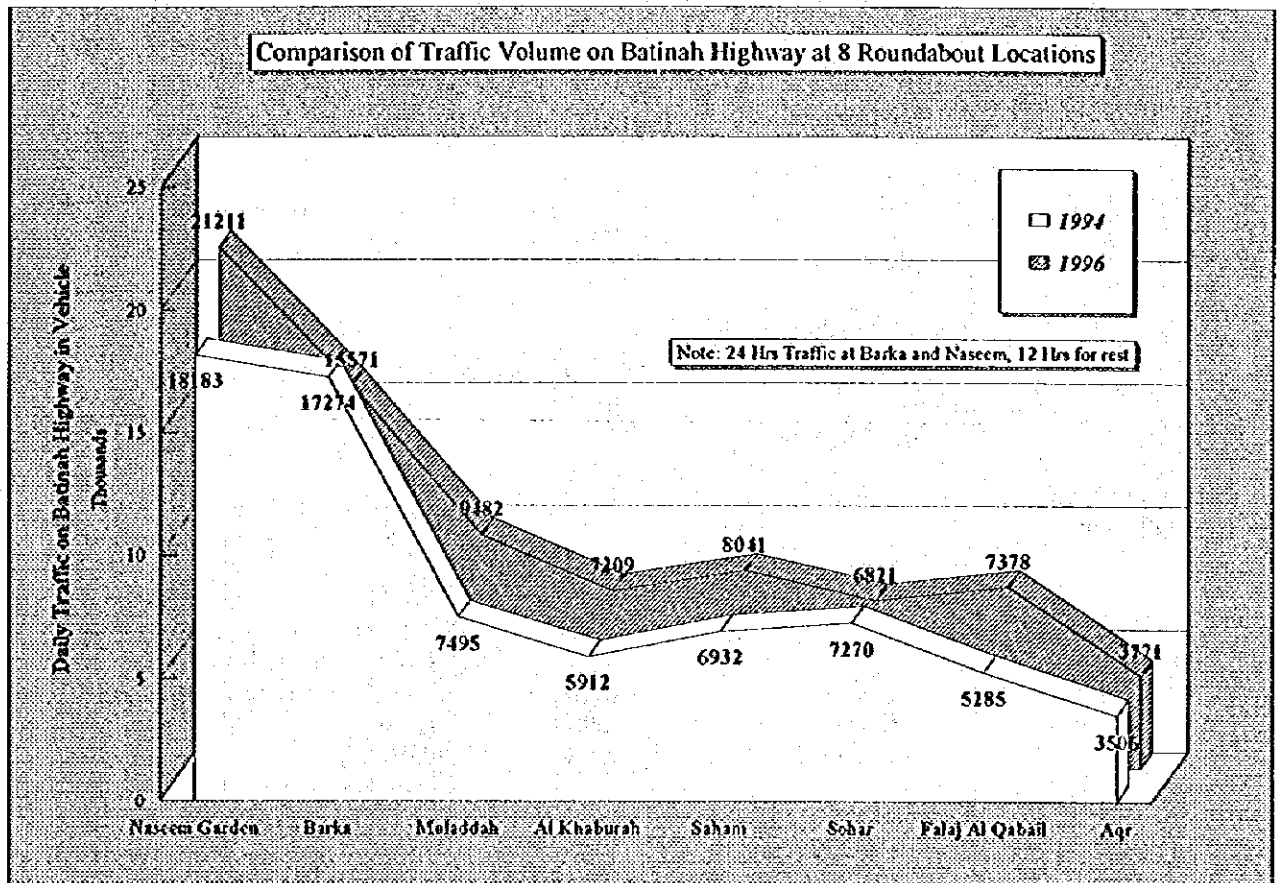


Figure I. 6. Comparison of Traffic Volumes on Batinah Highway between 1994 & 1996

### (2) Traffic Volume Increases on Minor Cross Roads

One of the important findings of this study is the higher traffic volume increases on the cross roads of Batinah Highway. Table 12.9 shows this analysis of traffic volume growth rates between 1994 and 1996. Traffic on the cross roads increase on an average of about 10-15% a year. Again there are variations of such increases between locations. Higher rates of increases are found at National Route No. 11 at Muladdah Junction, Route No. 9 at Khaburah R/A, Route No.8 at Sohar R/A, Route No.7 at Falaj Al Qabail R/A. Smaller increases are found at Saham R/A, Aqr R/A. The exceptionally high rates found at Naseem Garden is due to changes to traffic behaviour accessing and exiting the service roads to the roundabout as observed on site. Traffic from Muscat, for instance, could exit the highway to the coastal service road via a number of exit points (notably the one just before the R/A to a gas station) but have to re-enter the highway at the roundabout only. This explains also the imbalance in entry and exit traffic volumes on the minor roads at this roundabout.

Table I. 9: Average Annual Traffic Growth Rates on Crossroads at 8 R/A Locations

No.	Name of R/A	Year	To Coast Total 2-Dir Traffic	To Inland Total 2-Dir Traffic	Remarks
R-2	A'Naseem Gar. (24 Hours)	1996	1,946	2,084	To service road only To service road only
		1994	418	686	
		Change	1,528	1,398	
		Ave.A.G.R %	115.8%	74.3%	
R-3	Barka (24 Hours)	1996	8,168	8,353	National Route 13 to Nakhal To Coastal Town
		1994*	9,824	7,280	
		Change	(1,656)	1,073	
		Ave.A.G.R %	-8.8%	7.1%	
R-5	Al Mulladah (12 Hours)	1996	-	5,095	Inland to National Route 11 for Rustaq
		1994	-	3,665	
		Change	-	1,430	
		Ave.A.G.R %	-	17.9%	
R-8	Al Khaburah (12 Hours)	1996	5,936	4,780	Inland to National Route 9 and coastal to Khaburah town
		1994	4,154	2,874	
		Change	1,782	1,906	
		Ave.A.G.R %	19.5%	29.0%	
R-10	Saham (12 Hours)	1996	6,916	6,986	Coastal to Saham Town
		1994	6,190	6,505	
		Change	726	481	
		Ave.A.G.R %	5.7%	3.6%	
R-12	Sohar (12 Hours)	1996	14,883	7,844	Coastal to Sohar Town Inland to Wadi Hibi village on N.Route 8
		1994	12,996	5,325	
		Change	1,887	2,519	
		Ave.A.G.R %	7.0%	21.4%	
R-14	Falaj Al Qabail (12 Hours)	1996	2,180	3,865	Inland to National Route 7 for Buraimi Town & coastal to Falaj Al Qabail village
		1994	1,190	2,316	
		Change	990	1,549	
		Ave.A.G.R %	35.3%	29.2%	
R-18	Aqr (12 Hours)	1996	346	2,811	Inland to National Route 5 for Dubai & coastal to village
		1994	308	2,178	
		Change	38	633	
		Ave.A.G.R %	6.0%	13.6%	
Average on selected locations			9.6%	15.4%	

Notes \* Expanded from 12 hours traffic data  
Average on cross roads exclude Naseem Garden R/A and Falaj Al Qabail



The interpretation of these higher increases is chiefly due to increases in local traffic, between the inland and coastal towns. Nevertheless, traffic on the cross roads are general not very high when compared to the Batinah Highway. Except for Sohar R/A where the cross road traffic exceeds 10,000 veh for 12 hours, traffic on the other cross roads are between 2,500 to 8,000 veh/day.

### (3) Traffic Composition

Changes in the composition of traffic both on Batinah Highway and the minor cross roads are marginal since 1994. The general average traffic composition remained fairly stable, with passenger cars and pickup trucks comprising more than 80% of the traffic. Figure I. 7 shows the comparison of traffic composition at the eight study roundabouts between 1994 and 1996. There are more medium trucks at Saham, Sohar and Falaj Al Qabail roundabouts in 1996 compared to 1994. But still the increases are only about 5-6%. More important is the share of large trucks which has remained constant at below 5%. Table I. 10 compares the traffic composition for 1994 and 1996 at the 8 study locations.

Table I. 10 : Comparison of Traffic Composition on Batinah Highway, 1994-1996

Location	Year	Car/Taxi	Pickups	Med.Truck	Hvy Truck	Bus
R/A-2: Naseem gar.	1996	78.8%	17.9%	1.3%	1.9%	0.2%
	1994	71.8%	25.0%	1.4%	1.6%	0.2%
R/A-3: Barka	1996	71.4%	24.9%	1.5%	2.1%	0.1%
	1994	71.8%	25.0%	1.4%	1.7%	0.1%
R/A-5: Al Muladdah	1996	70.6%	24.4%	1.7%	2.2%	1.1%
	1994	66.3%	29.2%	1.6%	2.8%	0.1%
R/A-8: Al Khaburah	1996	63.1%	32.6%	1.4%	2.7%	0.2%
	1994	62.1%	33.1%	0.9%	3.7%	0.2%
R/A-10: Saham	1996	53.3%	35.6%	7.0%	4.0%	0.1%
	1994	58.8%	37.7%	1.2%	2.2%	0.1%
R/A-12: Sohar	1996	55.4%	30.1%	6.8%	3.8%	3.9%
	1994	55.1%	40.2%	1.6%	2.9%	0.2%
R/A-14: Falaj Al Qabail	1996	57.8%	33.3%	5.0%	3.2%	0.7%
	1994	62.6%	32.5%	0.8%	3.8%	0.3%
R/A-18: Aqr	1996	62.5%	33.0%	1.1%	3.4%	0.0%
	1994	65.8%	29.5%	1.0%	3.5%	0.2%

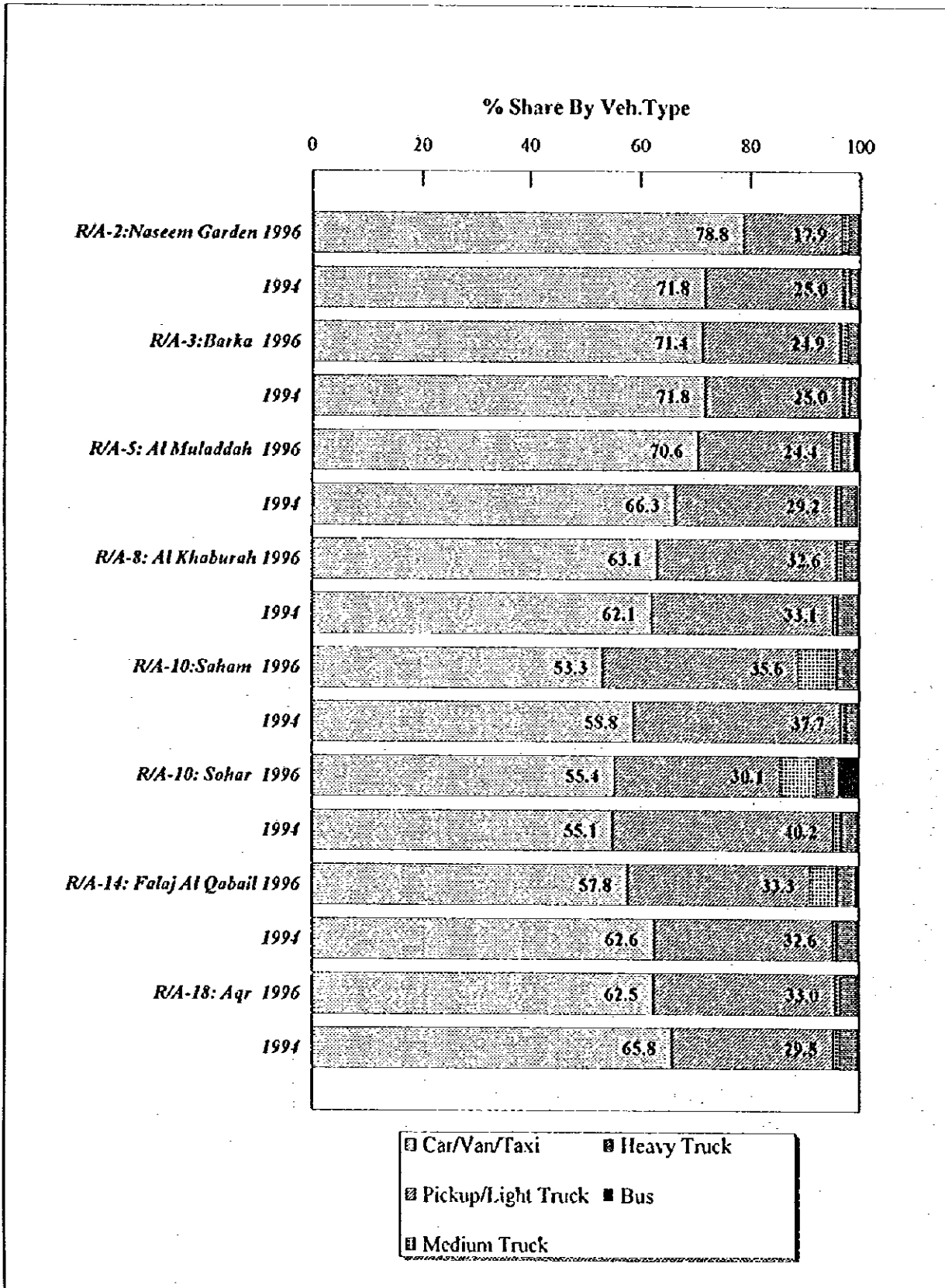


Figure I.7. Comparison of Traffic Composition on Batinah Highway, 1994 and 1996

#### **L 4 Review of Future Traffic Demand Forecasting**

##### **L 4.1 Review Method**

There are two major factors to be considered in reviewing the forecasted future traffic demand to year 2010 using the results and findings gathered from traffic surveys conducted in this study.

- (1) The total future traffic demand was projected in the F/S based on annual growth rate of 7.2%. This rate was derived based on the vehicle ownership growth trend of 7.9% a year as the upper limit and a traffic growth trend in Oman of 4.66% a year as the lower limit. In this study, the Batinah Highway traffic volumes, allowing for some variations, are found to increase at an average of 6.0-7.5% a year. This rate is therefore within the expected or assumed rate in the F/S. Revision to the total demand forecasted in the F/S is therefore judged not to be necessary.
- (2) The traffic survey in this study has however revealed a higher traffic growth trend on the minor roads. These increases need to be considered in the future demand projections. The increases of traffic on these minor roads are judged to be due to local traffic. To account for these traffic, minor adjustment to the OD table is required. OD pairs, such as between Sohar town and Wadi Hibi, are identified and their trip attractions duly adjusted.

Figure I. 8 shows the procedure in reviewing the future traffic demand at the eight roundabouts.

1. The first step is to estimate the total traffic demand in 1996 using the average traffic growth rates computed from the traffic surveys. The total traffic demand for 1996 is estimated by expanding the 1994 demand at an annual rate of 7.5%. Using the latest 1993 population census figures for the wilayats in Batinah Region, the estimated traffic demand in 1996 is redistributed.
2. Traffic OD pattern in the previous 1994 OD table is revised by identifying the OD pairs found in the survey to have higher traffic growth rates, and increasing the attraction between these OD pairs.
3. A 1996 OD table is hence prepared by recomputing the matrix using the estimated 1996 traffic demand by zones and the revised OD pattern table.
4. The 1996 OD table is then used for traffic assignment using the computer model The Highway Emulator as in the F/S study to simulate traffic volume on the existing road network.

5. The simulated traffic volumes are compared to those surveyed on site. Several iteration of step-5 are carried out to arrive at a OD pattern that is capable of simulating the surveyed traffic volumes.
6. The future OD table in the F/S study is revised to take into account the new OD attraction pattern verified above, but maintaining the unchanged future population distribution and total traffic demand increase ratio of 2.9.
7. Finally the revised future 2010 OD table is assigned to the future road network to obtain the future forecasted traffic volumes on the road links.

#### **I. 4.2 Verification of Revised OD Table with 1996 Survey Results**

Applying the average annual traffic demand growth rate of 7.5% to the 1994 estimated traffic volume of 69,890 trips/day within the Batinah region, the total 1996 traffic demand was first estimated to be about 81,000 trips/day. These total of trips were then distributed to the traffic zones using the 1993 population census figures. The 1996 OD table prepared hence was then used to assign traffic demand onto the existing road network.

The assigned traffic volumes on the road network links were then compared to those observed on site. Several iteration were tried and the iteration where simulated traffic volumes almost equal to the observed traffic volumes as a whole on the network is taken to be the best results.

Figure I. 9 shows the comparison analysis of 1996 simulated traffic volume with the surveyed traffic volume. The simulated traffic volumes are within acceptable levels to the observed traffic volumes.

The 1996 OD table pattern used in this assignment is then adopted to be final OD pattern for revision of the future 2010 OD table.

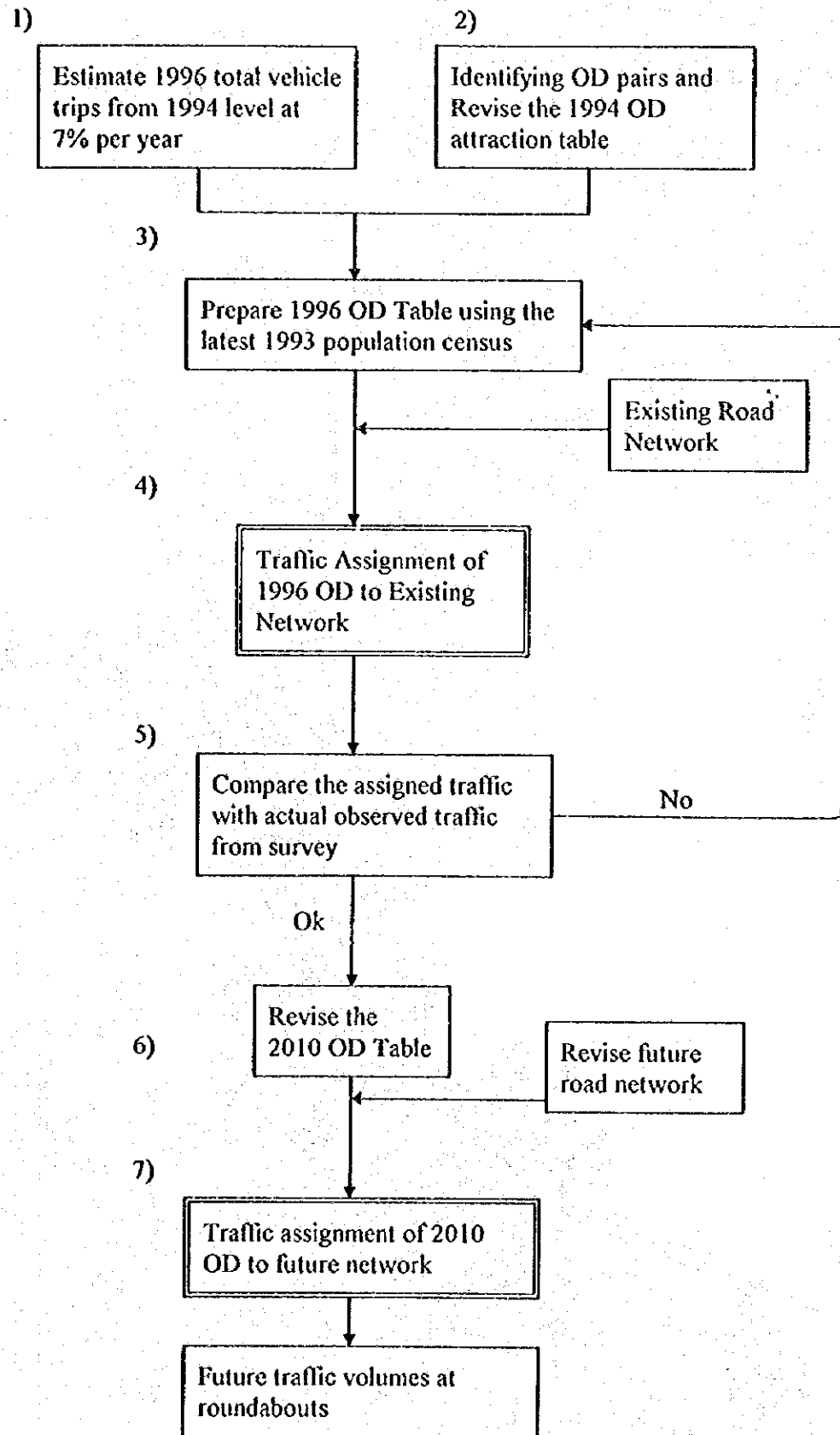


Figure I. 8. Procedure for Reviewing Future Forecasted Traffic Demand



#### **I.4.3 Forecasted Future 2010 Traffic Volume on Road Network**

Although the total future traffic demand in the Batinah Region remains as it was projected in the F/S, the revised OD table pattern needs to be applied to obtain the new future traffic demand on the future road network.

Following the verification of the revised OD table in 1996 described in the section above, the total traffic demand for the year 2010 estimated in the Feasibility Study at about 220,000 trips/day was distribution to the traffic zones and a revised 2010 OD table was prepared. Since no other new road construction has been committed since the Feasibility Study, the future road network prepared in the F/S study is taken to be the applicable future road network in this study. The revised 2010 OD table is then assigned to the future road network.

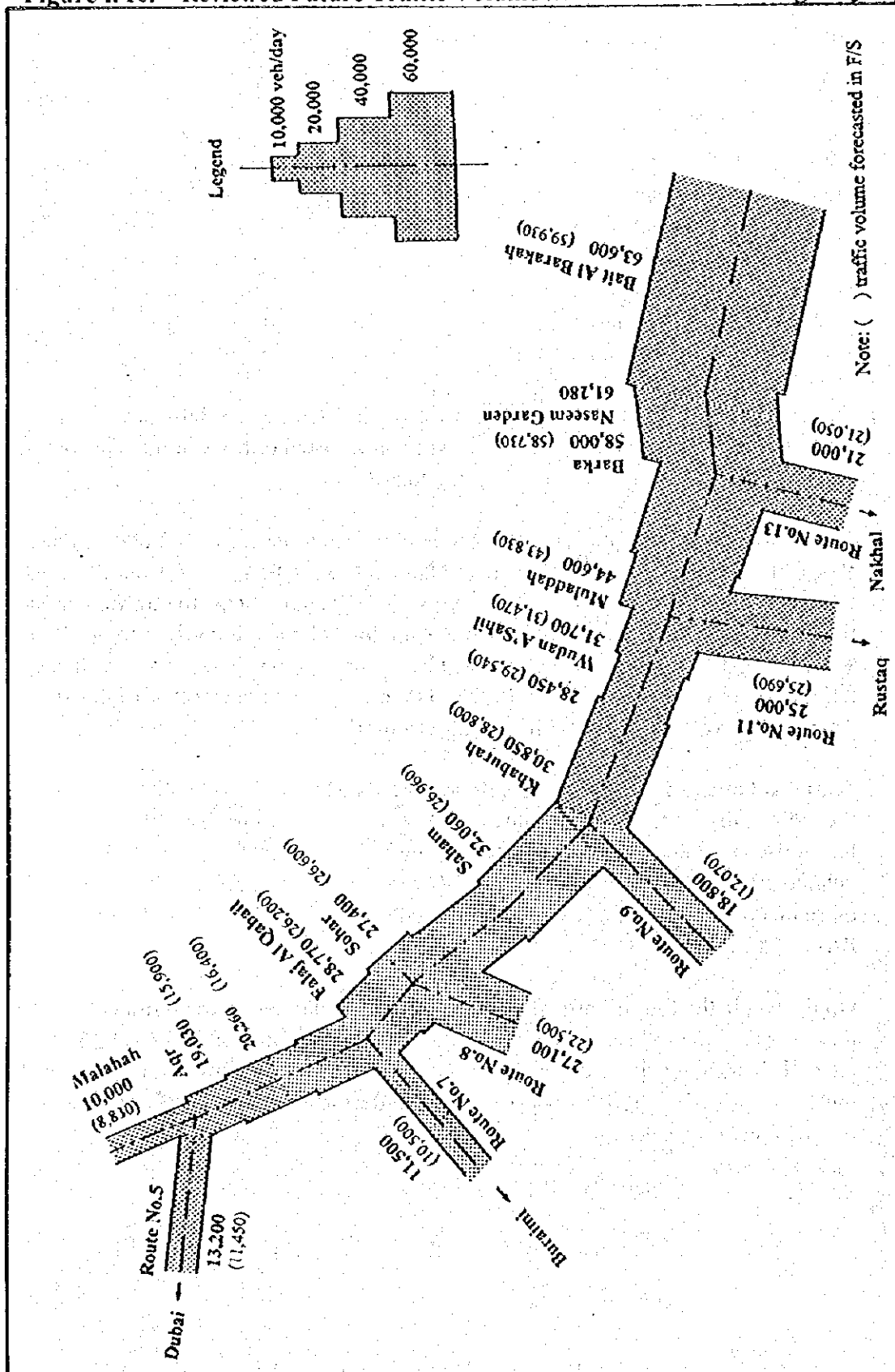
Figure I. 10 shows the forecasted traffic volume in 2010 for the Batinah Highway and the adjoining roads. As a reference, the previous forecasted traffic volume reported in the 1994 Feasibility Study is also given in the figure.

Traffic volume in 2010 along the Batinah Highway is forecasted as 63,600 veh/day near Bait Al Barakah R/A, 61,200 veh/day at Naseem Garden R/A, 58,000 veh/day at Barka R/A, 44,600 veh/day at Muladdah Junction. At Khaburah R/A, the traffic volume is forecasted to be 30,850 veh/day, and at Saham, the volume is estimated to be 32,060 veh/day. At Sohar R/A, the volume will be about 27,400 veh/day, and it will decrease to 24,700 veh/day at Falaj Al Qabail R/A and then 19,030 veh/day at Aqr Roundabout. These traffic volumes do not differ greatly from the previous 1994 F/S s forecasts.

Traffic volumes on the adjoining roads are forecasted to be equal or slightly higher than the 1994 study. Traffic on Route no. 13 to Nakhal remains unchanged at 21,000 veh/day, but traffic on route No. 9 at Khaburah will be higher at 18,800 veh/day and 27,100 veh/day on route no. 8 at Sohar R/A. Traffic volumes in 2010 will be 11,500 veh/day on route no.7 at Falaj Al Qabail R/A and finally 13,200 veh/day on route no.5 at Aqr R/A.

On the whole the future traffic demand pattern and volumes on the Batinah Highway therefore is found to be very similar to the scenario presented in the Feasibility Study. Nevertheless, the revised future forecasted traffic demands are further applied for the ranking of priority in flyover construction and for the computation of capacity in highway and bridge design.

Figure I. 10. Reviewed Future Traffic Volume in 2010 On Batinah Highway





#### I.4.4 Forecasting Future Traffic Demand on Proposed Flyovers

As in the previous Feasibility Study, a hypothetical road network in 2010 with new links added to represent the proposed 8 flyovers at the 8 roundabouts is first prepared. Next, the future OD table is used to assign the traffic demand on to this network. Traffic demand on these hypothetical links are therefore the expected future traffic volumes on the flyovers. Table I. 11 below shows the forecasted future through traffic on the proposed flyovers at the 8 locations. These through traffic volumes do not differ from those forecasted in the previous Feasibility Study.

**Table I. 11. Forecasted Traffic Demand on Flyovers**

Name of Roundabouts	Surveyed Thru Traffic In 1996	Forecasted Thru Traffic in 2010
Naseem Garden R/A	19,609	56,000
Barka R/A	10,674	32,000
Muladdah Junction	11,288	25,000
Al Khaburah R/A	7,199	25,000
Saham R/A	7,202	21,500
Sohar R/A	4,131	14,700
Falaj Al Qabail	7,237	18,000
Aqr R/A	3,589	11,000

The through traffic volumes will increase from about 20,000 veh/day at Naseem Garden to more than 56,000 veh/day by the year 2010. The share of this traffic to the total cross sectional traffic volume will remain fairly constant at about 90%. At Barka R/A, the through traffic will be more than 32,000 veh/day by 2010 compared to the 10,000 veh/day in 1996.

Through traffic volumes by the year 2010 are forecasted to be about 25,000 veh/day at Muladdah Junction and Khaburah R/A compared to 11,300 veh/day and 7,200 veh/day respectively in 1996.

Through traffic at Saham R/A is expected to reach 21,500 veh/day by 2010 with a higher share to the total traffic. Similarly, through traffic share at Sohar will be slightly higher with a volume of 14,700 vehicles/day. Future through traffic volume at Falaj Al Qabail R/A is expected to reach 18,000 veh/day while it will be 11,000 veh/day at Aqr R/A.

#### I.4.5 Traffic Volume at the Roundabouts and Implications for Design of Flyovers

Figures I. 11 through I. 14 show the forecasted traffic volumes on Batinah Highway and cross roads at the eight study roundabouts. In these figures, the left- and right-turning traffic on the highway by directions are indicated as traffic on the rampways. The through traffic is also shown in these figures as traffic on the flyovers.

The latter two are in fact important traffic volume figures for considerations in the design of the flyovers and rampways. In this D/D study, the design capacity for one lane on the flyover is taken to be 15,500 veh/lane/day at service level C with average speed of 120 kph, while on the rampway, the design capacity is 12,000 veh/lane/day at service level C with speed of 60 kph. Table I. 12 shows the number of lanes required for the design of flyovers at the 8 locations. On the bridge section, traffic in 2010 is forecasted to be 56,000 veh/day at Naseem Garden R/A to 11,000 veh/day at Aqr R/A. As in the Feasibility Study, the main bridge section is therefore recommended to be a 4-lane divided highway section. The rampway at the bridges are recommended to be one lane except at Barka R/A towards Muscat, where traffic in future is expected to exceed 13,000 veh/day, and hence two lanes are recommended.

**Table I. 12 : Number of Lanes Required for Flyovers**

Name of R/A	Section single direction	Traffic	Recommended
Naseem Garden R/a	Bridge	28,000 veh/day	2 lanes
	Ramps	2,660	1 lane
Barka R/A	Bridge	16,000	2 lanes
	Ramp(Muscat)	13,000	2 lanes
	Ramp(Aqr)	6,000	1 lane
Muladdah	Bridge	12,500	2 lanes
	Ramps	5,600	1 lane
Khaburah	Bridge	12,500	2 lanes
	Ramps	5,600	1 lane
Saham R/A	Bridge	11,750	2 lanes
	Ramps	5,160	1 lane
Sohar R/A	Bridge	7,350	2 lanes
	Ramps	7,540	1 lane
Falaj Al Qabail R/A	Bridge	9,000	2 lanes
	Ramps	5,420	1 lane
Aqr R/A	Bridge	5,500	2 lanes
	Ramps	4,020	1 lane

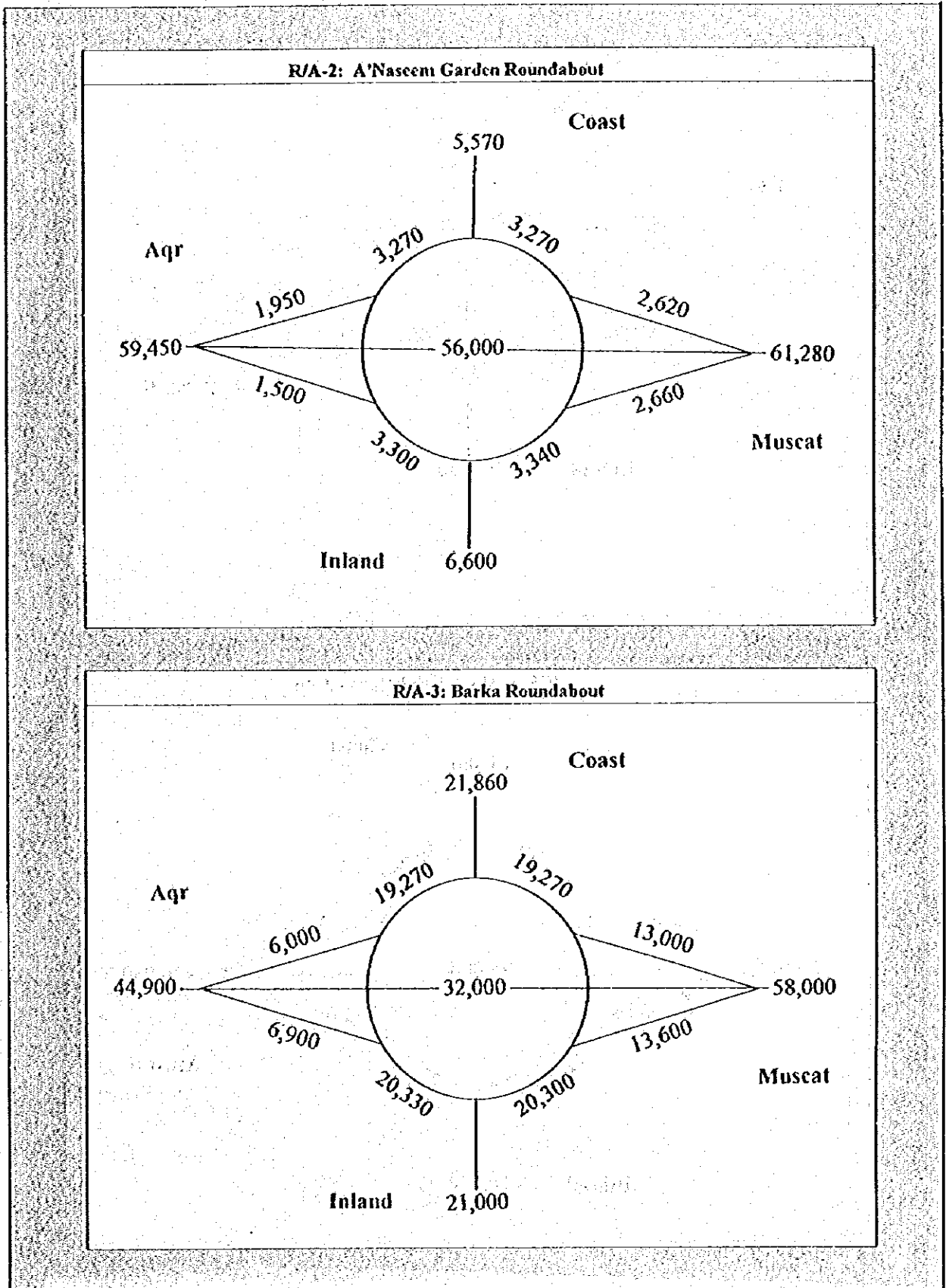


Figure I. 11: Traffic Volume at Naseem Garden R/A and Barka R/A in 2010

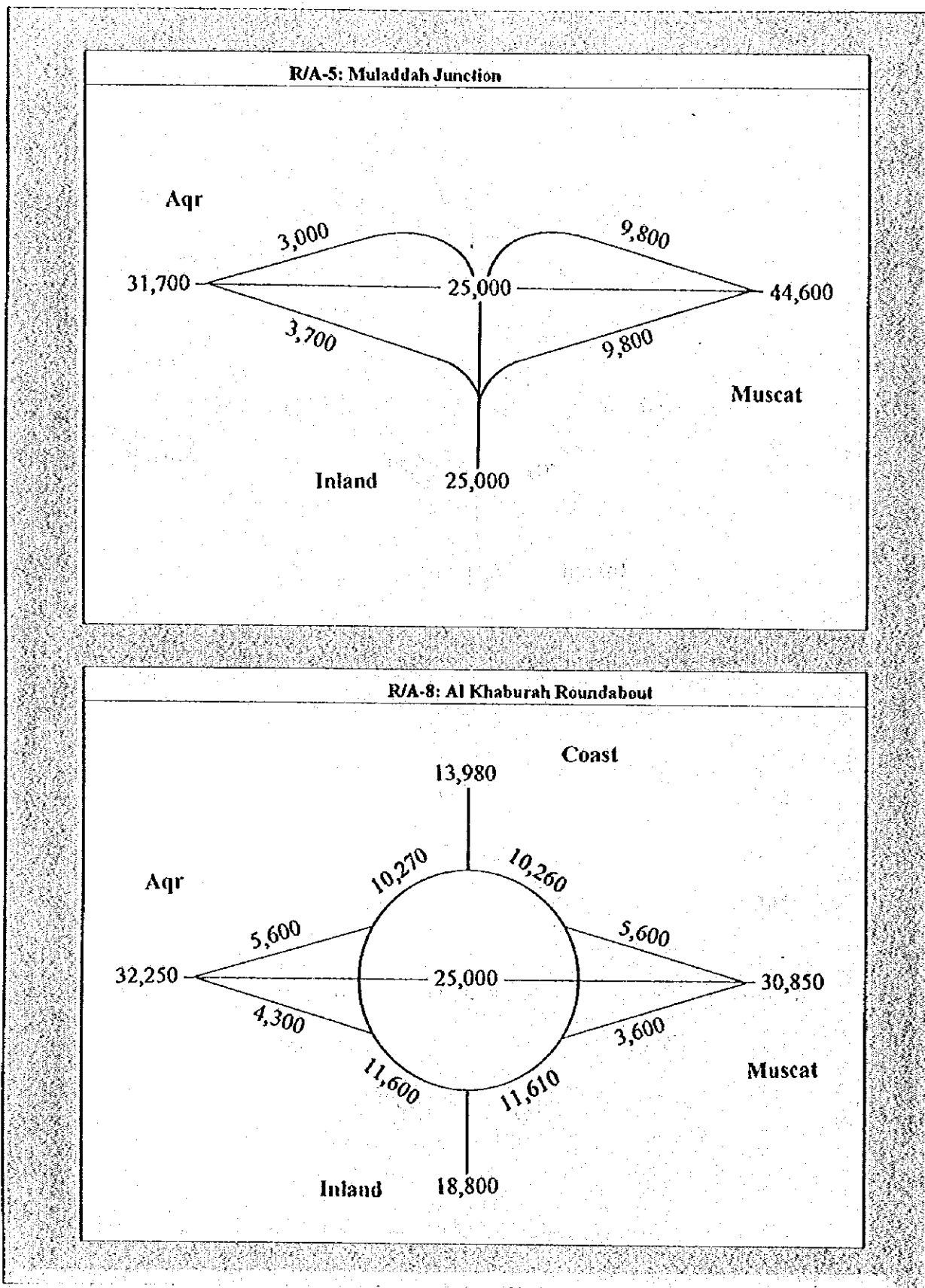


Figure I. 12. Traffic Volume at Al Mulladah Junction and Al Khaburah R/A in 2010

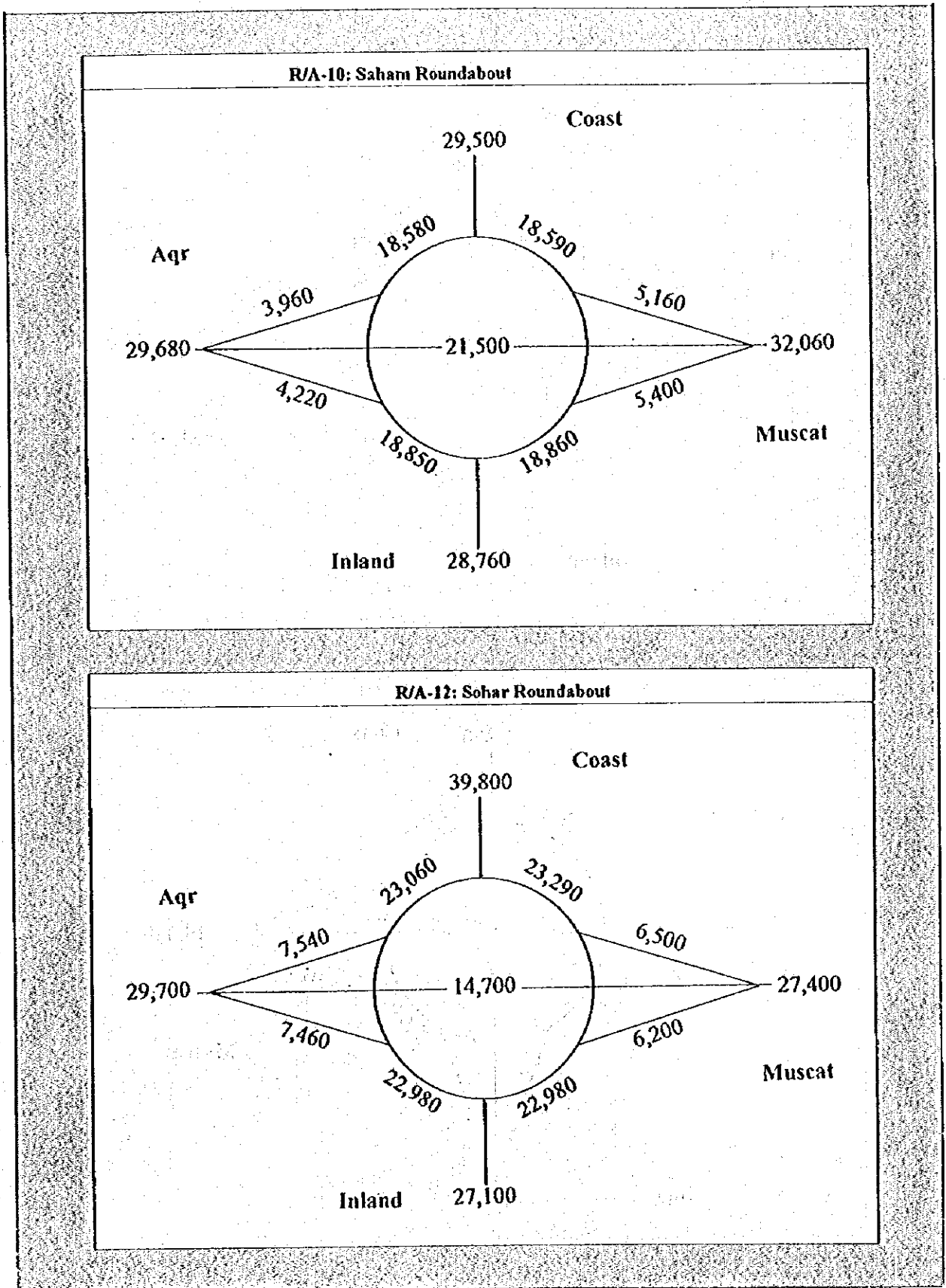


Figure I. 13. Traffic Volume at Saham and Sohar Roundabouts, in 2010

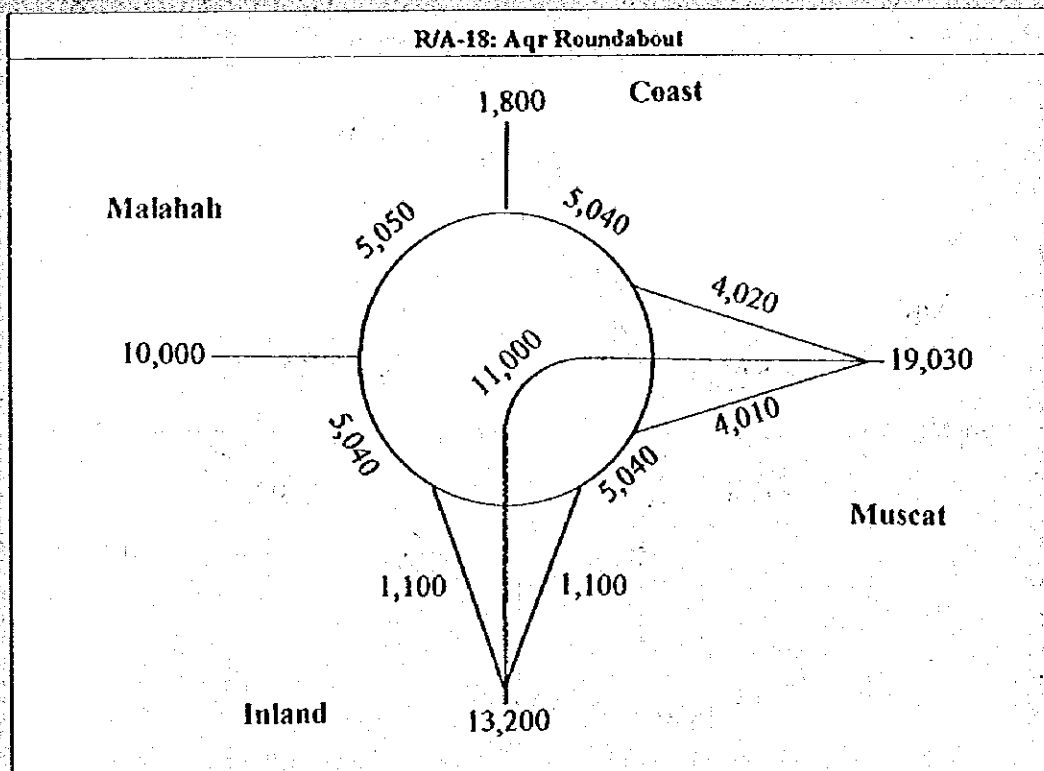
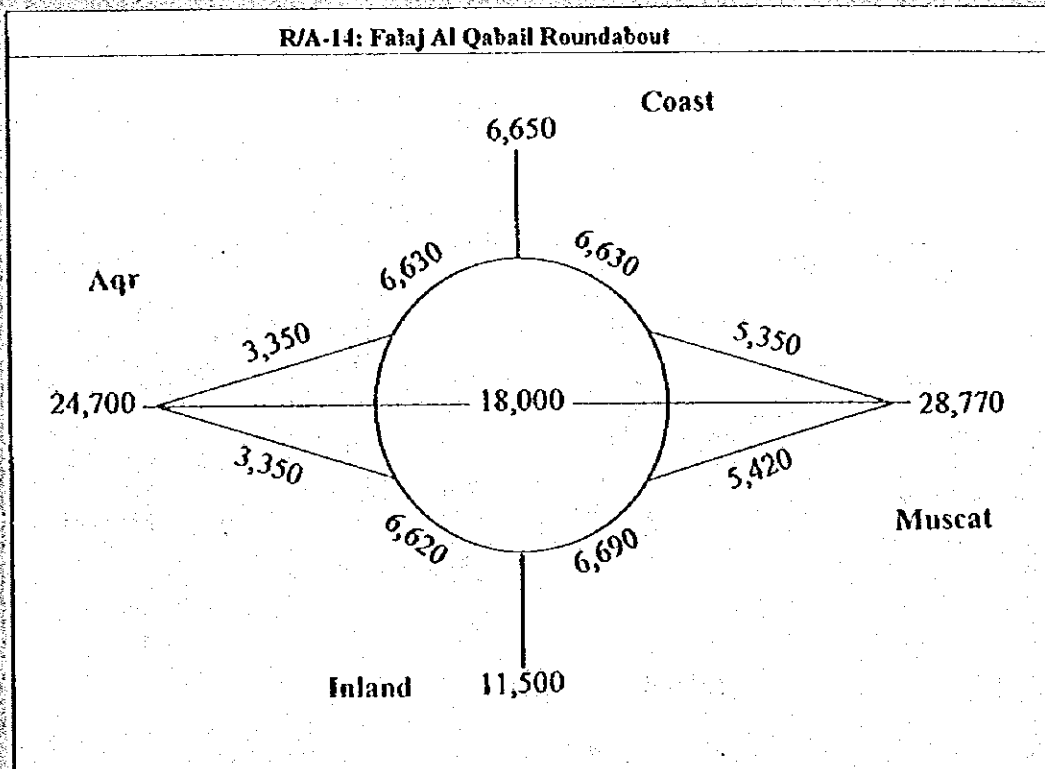


Figure I. 14. Traffic Volume at Falaj Al Qabail and Aqr Roundabouts in 2010

#### I. 4.6 Improvements to Cross Roads and Roundabouts

##### (1) Cross Road Improvements

The future forecasted traffic volumes on the cross-roads are expected to exceed the present two-lane capacity at a number of locations. Road widening improvements at these locations would be necessary to ensure smooth flow of traffic in the future. Table I. 13 shows the widening recommended for the cross-roads based on a capacity of 12,000 veh/day/lane at service level C and average travel speed of 70kph.

**Table I. 13. Road Improvements Recommended for Cross-Roads at R/A**

Name of R/A	To Coast		To Inland	
	Forecasted Future 2-dir. Traffic Vol.	Recommended Improvement	Forecasted Future 2-dir. Traffic Vol.	Recommended Improvement
R/A-2: Naseem Gar.	5,570 veh/day	-	6,600 veh/day	-
R/A-3: Barka	21,860 veh/day	Road widening to 4 lanes	21,000 veh/day (Route No.13)	Road widening to dual 2 lanes
R/A-5: Muladdah	-	-	25,000 veh/day (Route No.11)	Road widening to dual 2-lanes *
R/A-8: Al Khaburah	13,980 veh/day	-	18,800 veh/day (Route No.9)	Road widening to 4 lanes
R/A-10: Saham	29,500 veh/day	Road widening to dual 2 lanes	28,760 veh/day	Road widening to dual 2 lanes
R/A-12: Sohar	39,800 veh/day	Road widening to dual 2 lanes	27,100 veh/day (Route No.8)	Road widening to dual 2 lanes
R/A-14: Falaj Al Qabail	6,650 veh/day	-	11,500 veh/day (Route No.7)	-
R/A-18: Aqr	1,800 veh/day	-	13,200 veh/day (Route No.5)	-

\* Already Committed

As the above table shows, road improvement works will have to be carried out at Sohar Roundabout in particular, in view of the high traffic demand expected. At this roundabout, the cross road to Sohar Town on the coast and Wadi Ilibi to the inland area are recommended to be improved to dual carriageway 2 lane roads. Similar road improvements are also recommended at Saham and Barka Roundabouts.