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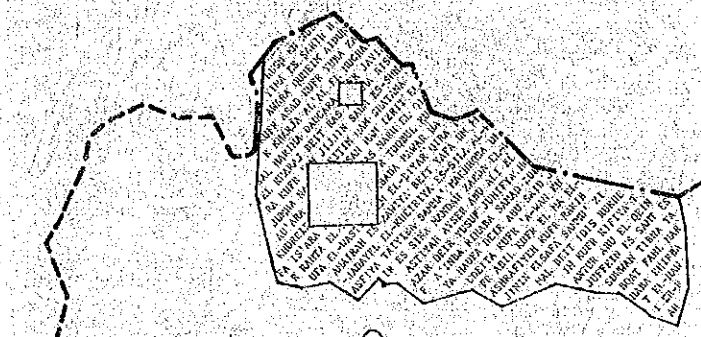
THE HASHEMITE KINGDOM OF
JORDAN

INTEGRATED REGIONAL DEVELOPMENT STUDY OF NORTHERN JORDAN
FINAL REPORT



Volume6: PART III, RESULT OF PHASE II STUDY
CHAPTER IV
Ring Roads

March, 1980
JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO

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INTEGRATED REGIONAL DEVELOPMENT STUDY OF NORTHERN JORDAN FINAL REPORT

Volume6: PARTIII, RESULT OF PHASE II STUDY CHAPTER IV Ring Roads

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TABLE OF CONTENTS: VOLUME 6

LIST OF TABLES AND FIGURES: VOLUME 6

Page

PART III (Continued)

CHAPTER IV

CHAPTER IV

RING ROADS OF IRBID

CHAPTER IV

RING ROADS OF IRBID

4.1 Background and Objectives

4.1.1 General

4.001 The City of Irbid is situated about 75 km north of Amman and is the largest city in the north of Jordan. For Irbid road transportation is the sole means for transporting passengers and goods within the city, or to other cities, notably Amman to the south, Baghdad to the east, Damascus via Ramtha to the north and the Jordan Valley to the west. According to the Department of Statistics, the city had a population of about 128,000 in 1975 after growing 7.8 percent per annum for 14 years.

4.002 It is also evident from the statistics that a rapid increase in the concentration of population is proceeding in the City of Irbid. Traffic conditions in the city have been aggravated and traffic accidents have increased as a consequence of the rapid growth of its population, and increased vehicle ownership. Further, one of the serious deficiencies of the road network in the city is that all the arterial roads pass through the central business district area so that through-traffic cannot avoid the congested area.

4.003 It is predicted that such traffic problem will become more serious in the future. In order to cope with the situation above, the Ring Roads project has been proposed.

4.004 Ring roads have been studied since 1970, by the Municipality of Irbid, as a part of city planning activities. The major objectives of the project are as follows: Firstly, the project is expected to mitigate the traffic congestion in the center of the city by attracting through-traffic to the ring road. Secondly, it would be helpful to the development of the outskirts of the city to provide a better transport medium. In addition, it will afford a framework to the city for a proper planning of land use, which will prevent the diseconomy of urban sprawl. There are three ring roads, in terms of their location: Inner Ring and Boundary Ring as has been planned by Irbid Municipality, and a third, Outer Ring which has been proposed by the Study Team. The construction of the Inner Ring and some work on the Boundary Ring is

presently going on. Accordingly, of the three ring roads, our main concern is a pre-feasibility study of remaining part of the Boundary Ring and the Outer Ring.

4.005 Our study was made according to the work flow chart shown in Figure 4.1.

4.006 A preliminary study for the realization of the project is described in the subsequent paragraph. The present condition of the road network and traffic demand in Irbid are described in Section 4.2. Traffic projections for the years 1985 and 2000 are made in Section 4.3. Based on the traffic projections, a better road network as well as alternatives for the economic study, are proposed in Section 4.4. A preliminary design of ring roads, according to the appropriate design criteria, is shown in Section 4.5. The construction and maintenance costs for the project are estiamted in terms of economic and financial costs in Section 4.6. By utilizing land prices and operating costs in the project area, the benefits accruing to the project are estimated for the economic evaluation in Section4.7. Finally, conclusions and recommendations are made in Section 4.8.

4.1.2 Description of the Ring Roads Project

4.007 The Municipality of Irbid has planned to construct two ring roads, the "Inner (First) Ring" and "Boundary (Second) Ring". Part of each is now under construction. Taking these two rings into consideration, the Study Team has proposed to plan the third ring, namely "Outer Ring", which will be located outside the Boundary Ring and almost on the boundary of the Irbid Municipality. The locations of the three rings are illustrated in Figure 4.2, and they are explained briefly hereunder.

a. Inner Ring Road

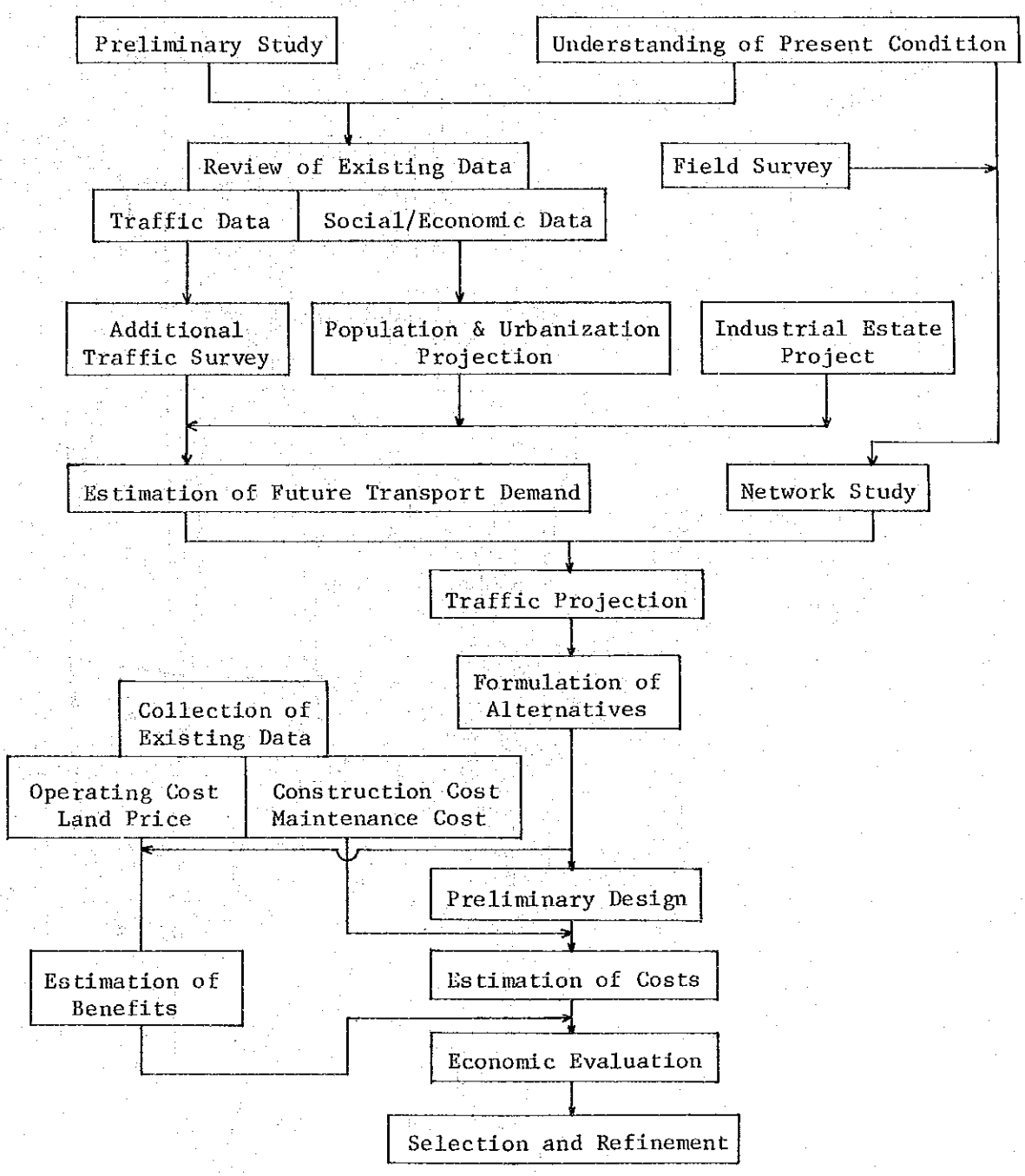
4.008 The Inner Ring Road is located at about 1.0 to 1.5 km from the center.

4.009 Although the Municipality of Irbid had planned to complete this ring at the outset, it has abandoned the construction of the northwest part of the ring, the reason being that because there is an established residential area there, vast amounts of compensation must be paid to residents in order to obtain a right-of-way and construct the road. The total length of the Inner Ring is about 8 km, out of which 3.5 km of the southwest part is open to traffic, and 3.5 km is now under construction. The right of way will be 20 m in width, and it will be used as a two-lane road for two-way

b. Boundary Ring Road

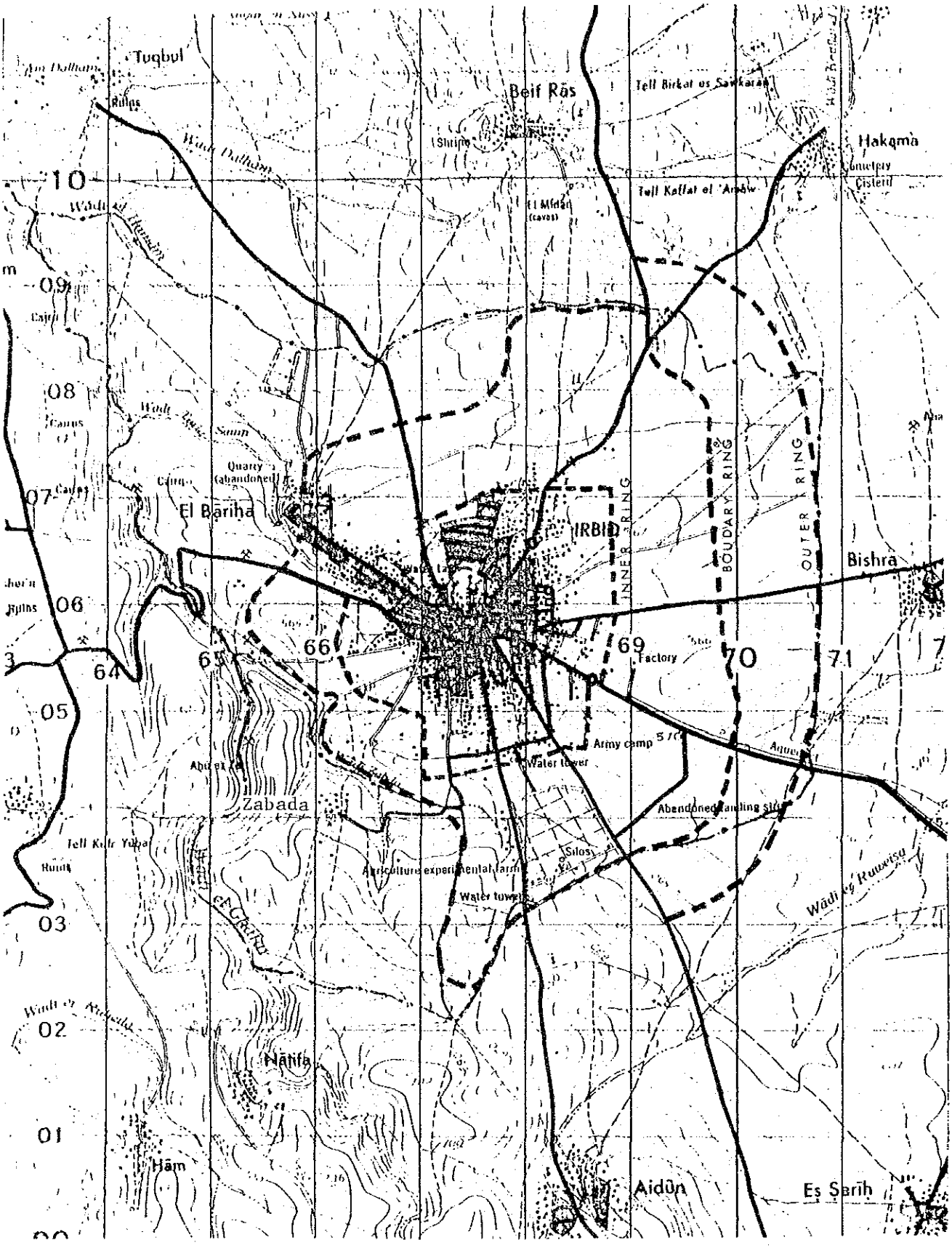
4.010 According to the plan made by the Municipality of Irbid, the Boundary Ring comprises a circle with a radius of 2.0 or 2.5 km. The total length of the Boundary Ring is approximately 18.2 km of which

Figure 4.1 Work Flow Chart for the Study of the Ring Roads Project in Irbid



Source: Study Team.

Figure 4.2 Location of Proposed Three Rings in Irbid City



Source: National Base Map.

Scale 1:50,000

5.9 km is now under construction. It is planned that the right-of-way will be 30 m in width and it will have four lanes. Most of the area along the ring is used for agriculture, mainly wheat production, with the exception of residential use along the existing radial roads.

c. Outer Ring Road

4.011 The Outer Ring Road is the one proposed by the Study Team and accepted by Jordanian officials, it should be located at a reasonable distance away from the Boundary Ring.

4.012 Only half of the Outer Ring, on the east side, should be considered for completion by 1985, taking into account the possible expansion of urbanized area, as depicted in Figure 4.2.

4.1.3 Preliminary Condition Study

4.013 Prior to the study of the Ring Roads Project, it is important to undertake a preliminary study to examine the soundness of institutional and financial conditions.

a. Institutional Aspect

4.014 The road network in the East Bank is classified into either national roads, administered by the Ministry of Public Works, and municipality roads, administered by the corresponding municipalities. Therefore, all the roads inside the city planning area of Irbid are managed and maintained by the Municipality of Irbid.

4.015 Even in the case when a road is outside the city planning area, if a cooperative arrangement about its finance is made among all the municipalities concerned with the road, it can be managed as a municipality road. Accordingly, if a ring road of Irbid is proposed to be located outside the city boundary, it will be made by either the coordination of the related municipalities as a municipality road, or the Ministry of Public Works as a national road. The construction and maintenance of roads are usually done by local contractors and sometimes directly by the Government. Local contractors seem to have enough capability to undertake the work.

b. Financial Aspect

4.016 According to the Municipality of Irbid, the annual budget for road development in fiscal 1978 was as follows:

Construction	JD 160,000
Maintenance	80,000
Supervision	20,000
Total	JD 260,000

4.017 These finances were allocated by the Ministry of Municipal and Rural Affairs. In addition to this, according to an Irbid City official, JD 140,000 for the construction of road shoulders and 25 percent of road construction cost were obtained from the corresponding land owners. Moreover, it is legally justifiable that land owners along the proposed route are obliged to provide the municipality with 25 percent of their land free of charge.

4.018 If necessary, the minicipality can get a special fund as a loan from the Central Government for a specific project.

c. Basic Road Alignment

4.019 On the basis of the pre-conditions stated above, the basic alignment of the Ring Roads should be determined.

i. Boundary Ring Road

4.020 As mentioned above, construction of a part of the Boundary Ring has been undertaken. With regard to the rest of the Boundary Ring, about 12.3 km as shown in Figure 4.3, several alternatives can be considered in addition to the original plan. One is the plan which makes the circle beyond the valley at the southwest city boundary and passes through Zabada and Kufr Yuba.

4.021 This alternative may yield a better accessibility to the Jordan Valley, since a driver would be able to avoid the valley section of Route 16 which has a poor alignment. Another one is the plan which encircles a broader area at the northwest part of the ring. This would provide additional space within the ring for futher development.

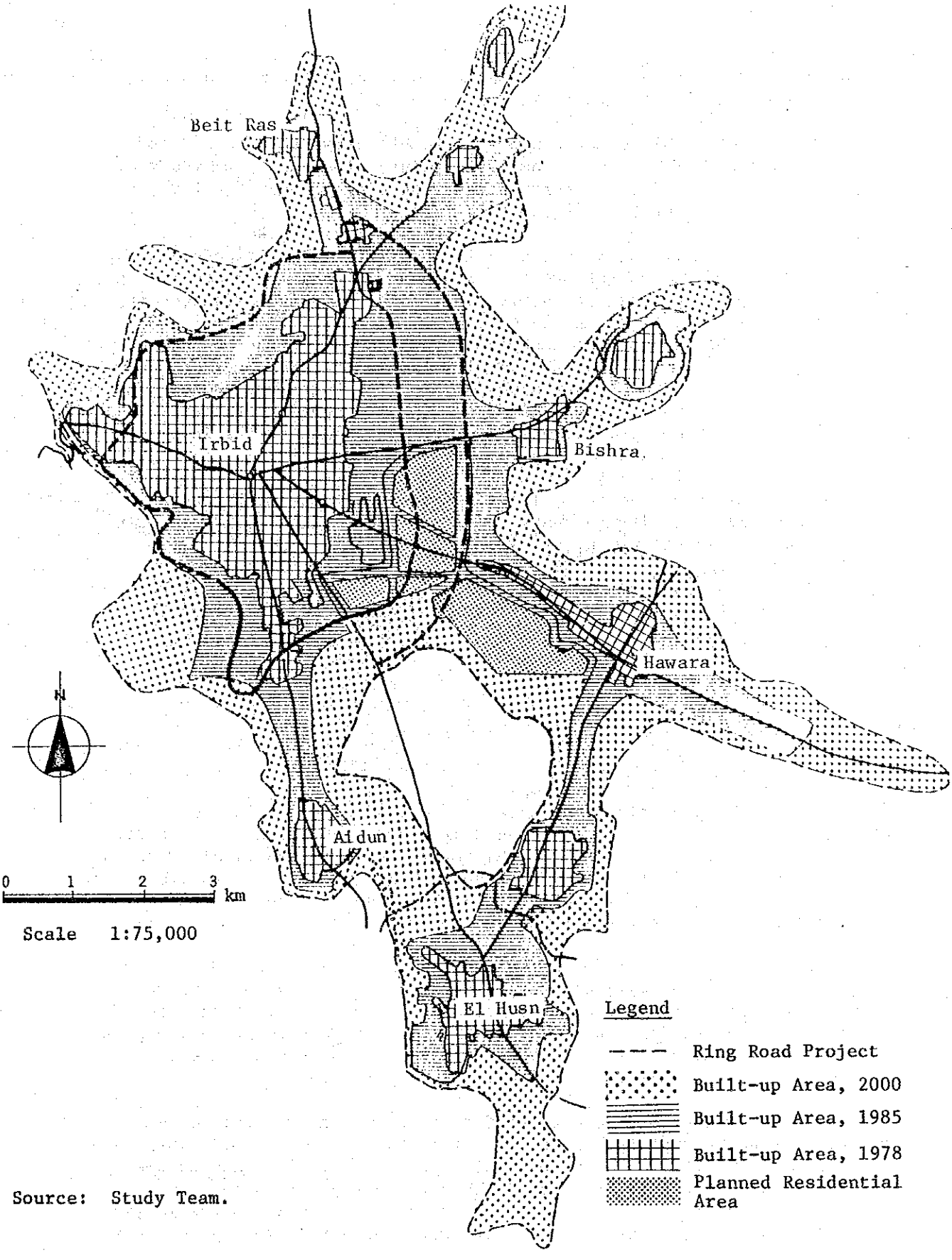
4.022 However, the study team has concluded that the original plan should be selected as the basic plan, from the viewpoint of the topography and the expansion of the city, though a section of it might have to be slightly modified. Namely, (1) the urbanization of the city cannot be expected to extend beyond the original ring at the west side by 1985, and (2) the valley at the southwest of the city would be an obstacle for the continuous utilization of land.

ii. Outer Ring Road

4.023 As to the Outer Ring, only half of the ring which is on the east side of Irbid should be discussed for the project by 1985, taking into account the possible expansion of urbanized area.

4.024 In terms of the basic alignments, two alterantive plans can be considered: one to be located around the city boundary, and the other to pass through the surrounding villages beyond the city boundary.

Figure 4.3 Irbid Urban Expansion and Ring Roads, 1978 to 1985



Source: Study Team.

4.025 The former is considered to be more preferable than the latter because of the following reasons:

(1) The former would be more efficient than the latter from the economic viewpoint, since urbanization would not reach further than the city boundary in 1985, as shown in Figure 4.3.

(2) In the latter case it is difficult and time-consuming to coordinate the city and villages concerned for the purpose of institutional and financial arrangements.

(3) One of the likeliest candidate sites for the new Industrial Estate of Irbid is located somewhere between the Boundary Ring and the City Boundary. Hence, the Outer Ring located on the City Boundary rather than outside it, will be more beneficial to the Industrial Estate.

4.026 As a consequence, it is proposed that the ring should be located near the city boundary and it be from Route 11 in the south to Route 23 in the north, as seen in Figure 4.4.

4.027 The approximate length of the Outer Ring may be 7.7 km. This ring will be extended to a complete circle in the future by adding the west part of the ring.

4.2 *Present Situation*

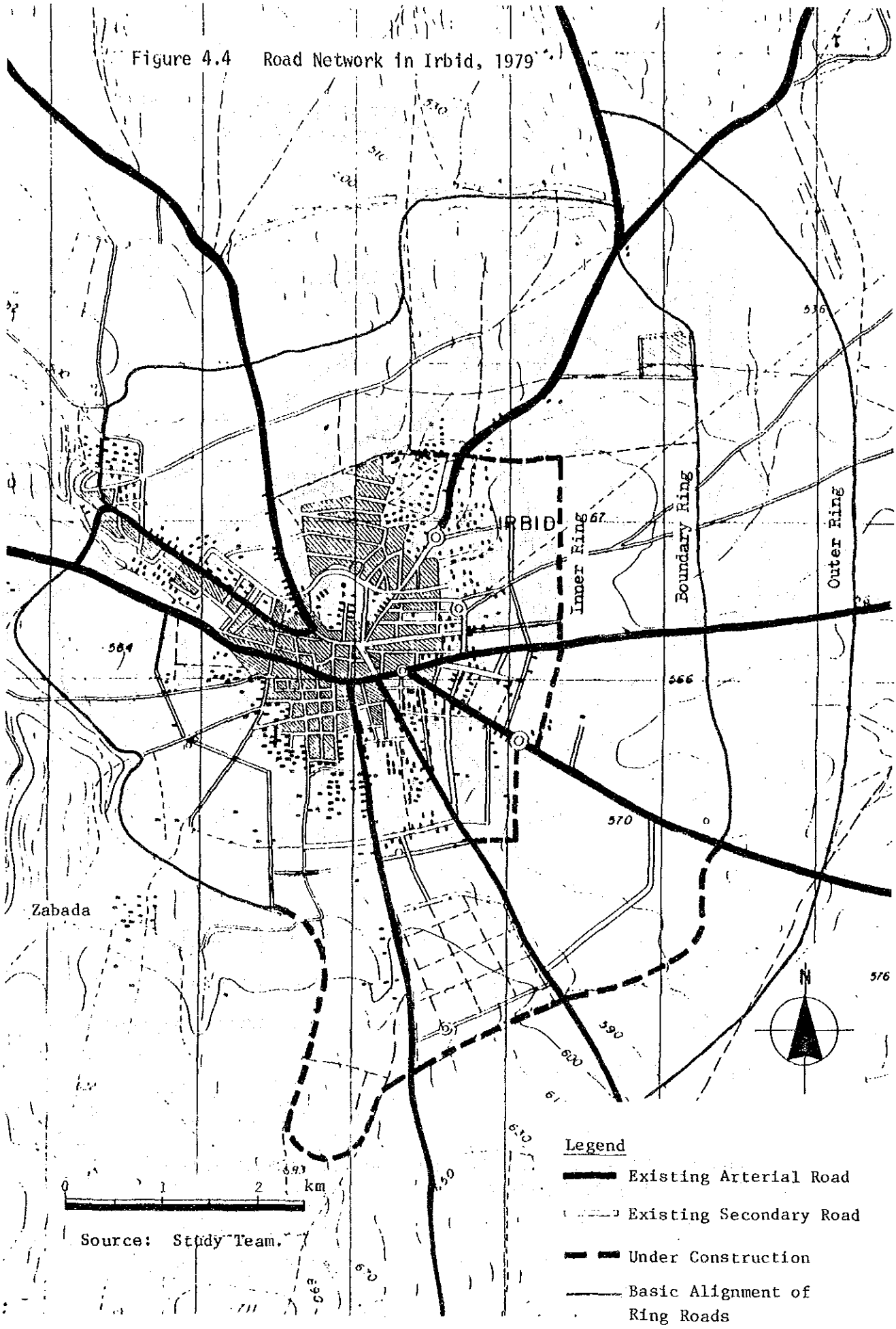
4.2.1 Existing Road Network in Irbid

4.028 The existing road network in Irbid is shown in Figure 4.4 which also shows the roads planned or under construction. According to the Municipality of Irbid, the total length of municipality roads was approximately 120 km as of August 1979, and the construction of an additional 7 km is going on, with 30 km planned to be constructed. About 20 km of the total is unpaved gravel road.

4.029 Arterial roads in the municipality have about 20 m to 30 m width of right-of-way; however, others mainly consist of narrow streets which are difficult to use as two-lane roads. Most arterial roads in the city are parts of the national road network, which pass through the center of Irbid. These national roads are Route 11, Route 16, and Route 23 as presented in Figure 4.5.

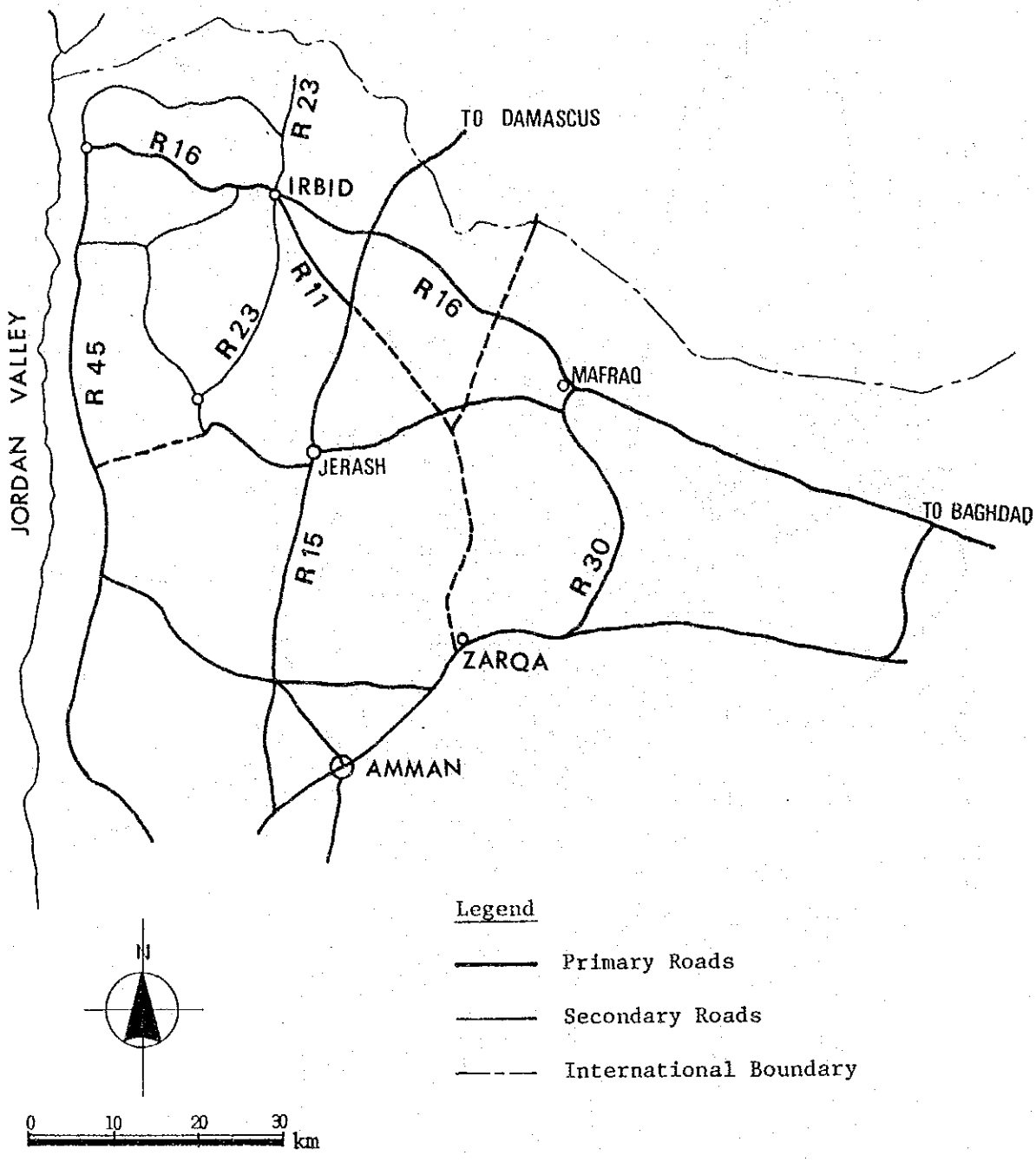
4.030 These roads are classified into two categories: either primary such as Routes 11 and 16, or secondary, Route 23. Among them, the most important and influential road is Route 11, which is now linked with Route 15 at about 17 km southwest of Irbid and will be extended to Zarqa, and will have four lanes, by 1982. Route 16, an east-west-road, connects Irbid City with the Jordan Valley in the west

Figure 4.4 Road Network in Irbid, 1979



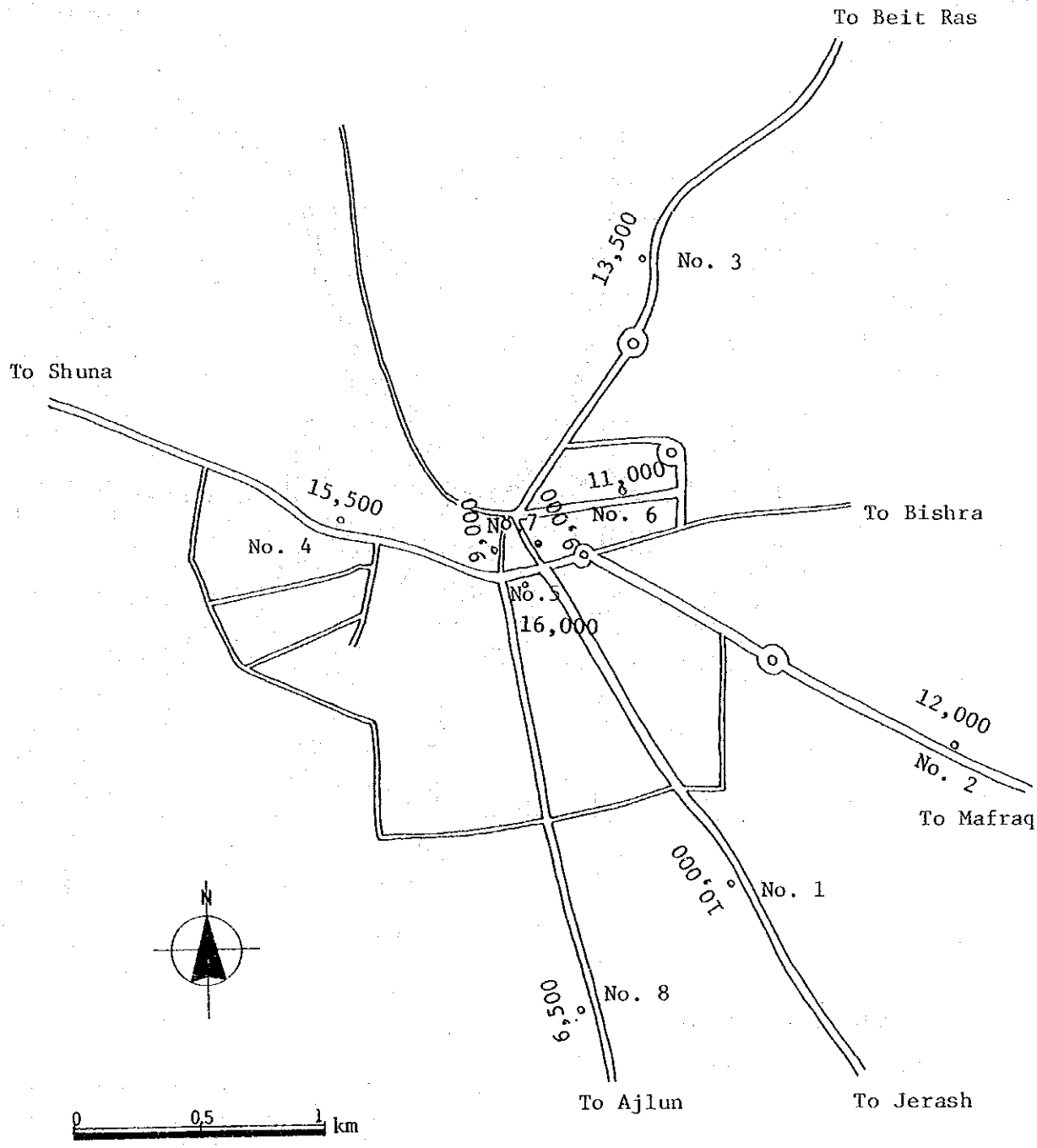
Source: Study Team.

Figure 4.5 Existing Interregional Roads of the Northern Part of Jordan, 1979



Sources: 1. Information from the Ministry of Public Works.
2. Master Road Plan.

Figure 4.6 Traffic Volumes in the City of Irbid, 1978



Scale 1:25,000

Legend

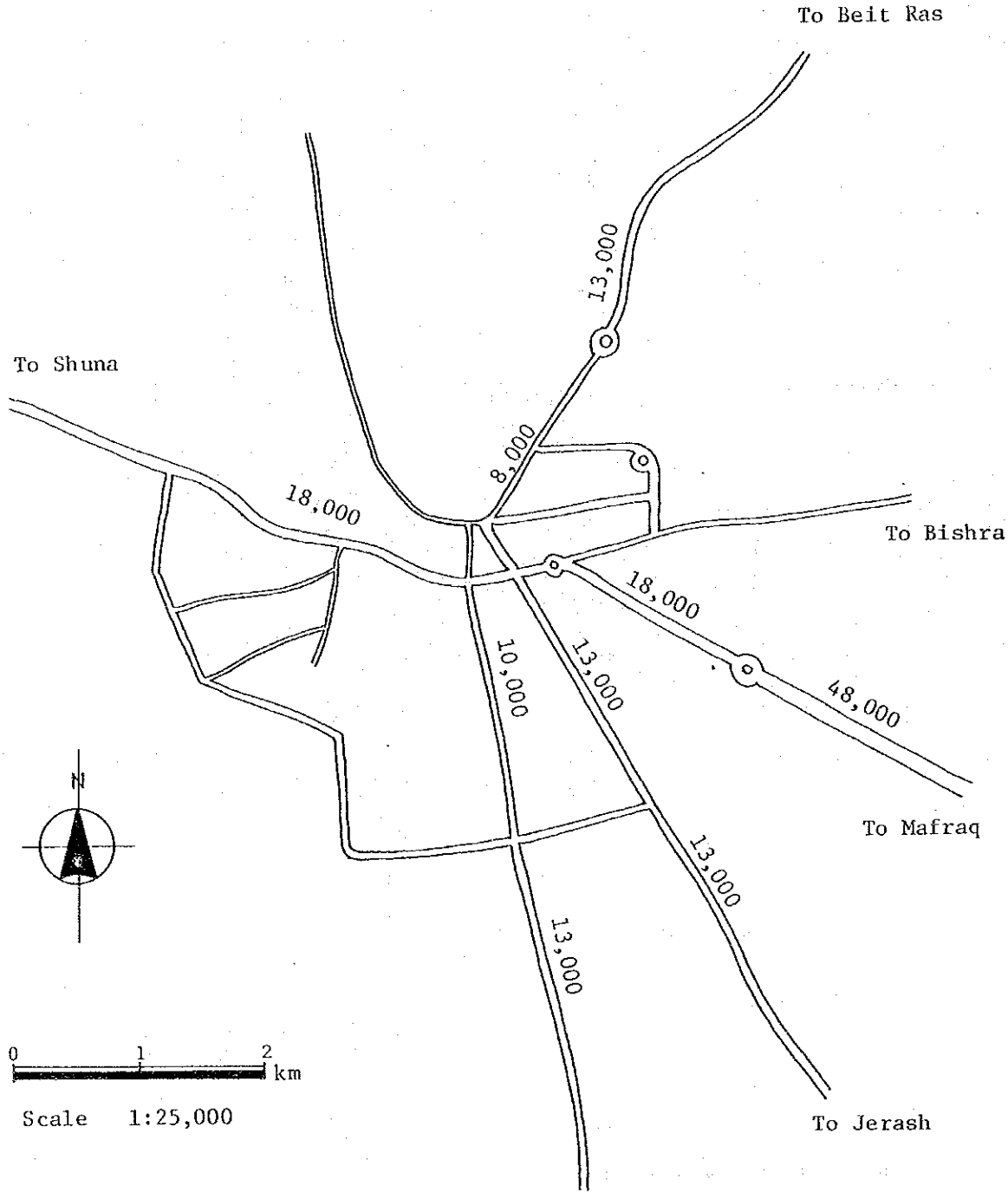
o : Count Station

6,500 : Estimated ADT in 1978

Source: Part II.

Note: No. 7 was estimated on one-way streets.

Figure 4.7 Capacity of Existing Roads, City of Irbid, 1979



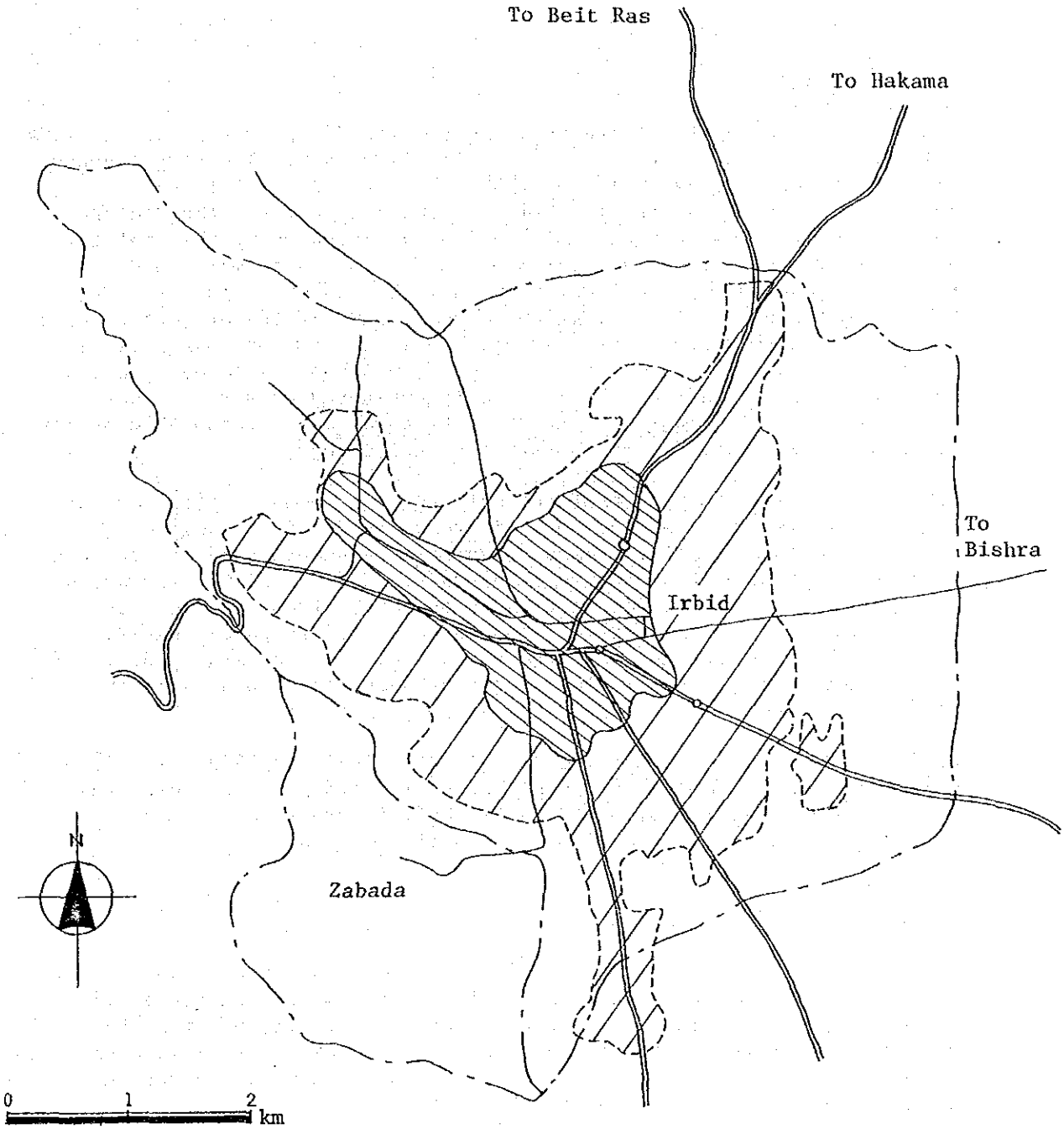
Legend

10,000 Capacity (vehicles/day)

Source: Study Team.

Note: These capacities were estimated by the same method as the one described on Table 4.8.

Figure 4.8 Expansion of Irbid City, 1978



Scale 1:50,000

Legend

- Built-up Area in 1952
- Built-up Area in 1978
- City Boundary
- Existing Trunk Road
- Existing Secondary Road

Source: Aerial photographs taken in 1978.

4.3 Traffic Projection

4.3.1 General

4.037 On the basis of the existing traffic data, traffic projections were made according to the flow chart in Figure 4.9. The target years for the projection are 1985 and 2000. The existing traffic data available for the traffic projection in the city are (1) the "Inter-regional Origin-Destination Table" which was prepared by the Ministry of Public Works in 1976, and (2) the traffic volume at main roads in the city, observed by the Study Team in 1978. However, an intracity O-D table for the city area, which is essential for the projection does not exist and therefore, the main problem is how to obtain a reliable estimate of the intracity traffic demand, which seems to be a dominant feature of urban traffic. It is usually estiamted by survey, that is, by interviewing residents in the city to obtain a reasonable number of samples, but this method is very time-consumong.

4.038 In our study, therefore, only the intracity traffic on the main roads was estimated and no estimate was made of the volume on the minor roads. Namely, it was calculated by subtracting the through-traffic and related traffic, related traffic defined as traffic which has either its origin or destination in the city, from the observed volumes at main roads in Irbid. Though these are rough estimates, they would not differ greatly from the actual ones at main roads if this information was available, since the observed volumes at main roads cover the largest part of interregional traffic.

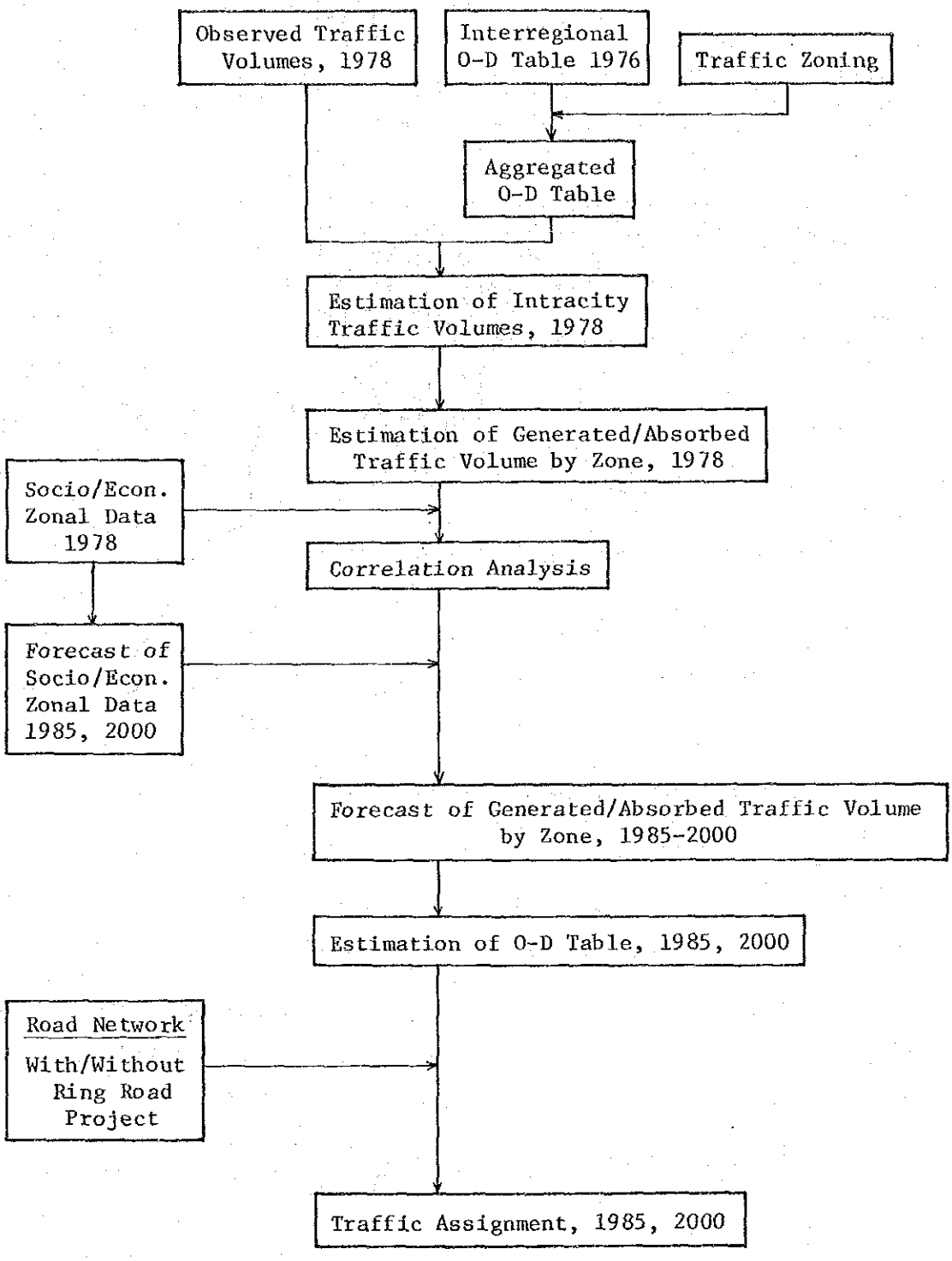
4.039 Using the estimated O-D tables for 1985 and 2000, traffic assignments were made using the alternative networks, i.e., with the Ring Roads Project and without the project, in order to find the project's effectiveness in terms of traffic volumes.

4.3.2 Traffic Zones

4.040 In the Part II, the traffic zones were determined as follows: The whole East Bank was divided into 56 traffic zones, of which 36 zones were in the Irbid Governorate, the City of Irbid being regarded as one zone. For the purposes of effective utilization of the existing O-D table which is the only one available, the zoning should be based on that given in the Part II.

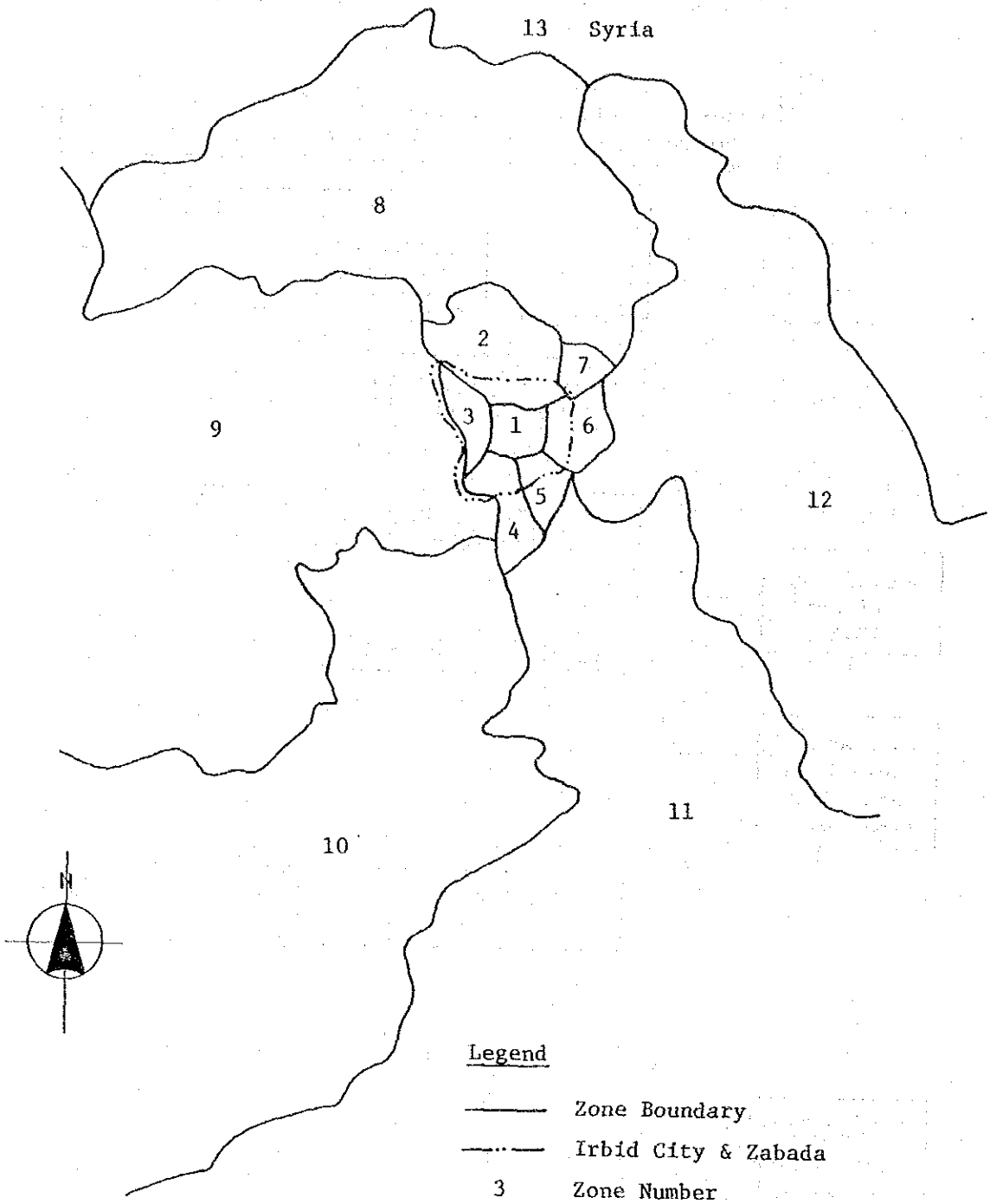
4.041 The City of Irbid was sub-divided into six zones for the purpose of estimation of project effectiveness, then the other areas, including neighboring countries, were aggregated into seven zones. As the consequence, the number of traffic zones were 13 in total, as presented in Figure 4.10. In this figure, the villages adjacent to Irbid are aggregated to the zones in Irbid.

Figure 4.9 Flow Chart for Traffic Projection



Source: Study Team.

Figure 4.10 Traffic Zones, Irbid City and Vicinity, 1979



No.	Zone Name	No.	Zone Name
1	Irbid CBD	8	Bani Kinara
2	Irbid N	9	Ghor
3	Irbid W	10	Ajlun
4	Irbid S	11	Jerash Amman
5	Irbid SE	12	Mafraq
6	Irbid E	13	Syria
7	Hakama		

Source: Part II.

4.3.3 Intracity Traffic

4.042 As stated at the beginning of this section, the estimation of intracity traffic volume at present is an indispensable step for the traffic projection on the Ring Roads. In 1978, a traffic survey was made at eight stations on the main roads in the City of Irbid.

4.043 The traffic volumes observed at those stations are composed of intercity traffic and intracity traffic. The intercity traffic can be derived from the "Interregional Origin-Destination Table in 1976", by taking account of the traffic growth during the years 1976 to 1978. Accordingly, the intracity traffic in 1978 is found by subtracting intercity traffic from the traffic volume observed at each station. This can be expressed in mathematical terms as follows:

$$Ii = Qj - Rj$$

where Ii: Intracity traffic volume generated or absorbed in zone i;

Qj: Observed traffic volume at cordon line[1/] j;

Rj: Intercity traffic volume at cordon line j calculated from the interregional O-D table.

The result of the calculation is shown in Table 4.2.

Table 4.2 Intracity Trip Ends of Irbid in 1978

(Unit: Vehicles/day)

Zone No.	1	2	3	4	5	6
Passenger Cars	20,731	7,874	7,828	3,838	5,476	12,911
Goods Vehicles	5,773	1,622	3,001	736	1,535	3,239
Total	26,504	9,496	10,829	4,574	7,011	16,150

Source: Study Team.

Note: "Intracity" means "within the area covered by zones 1 to 6".

The ratio of the intracity traffic to the total was found to be approximately 80 percent for passenger cars and taxis, and 70 percent for goods vehicles.

1/ Cordon line here is represented by count station on Figure 4.6.

4.044 The total trip ends by zones are calculated as follows:

$$Ti = Ii + Si$$

where Ti: Total trip ends in zone i;

Ii: Intracity trip ends in zone i;

Si: Intercity trip ends in zone i which can be derived from interregional O-D table.

4.3.4 Correlation Analysis

4.045 Traffic demand is obviously a result of socio-economic activities, therefore, the relationship between traffic volumes and socio-economic activities will give us a useful tool to use in forecasting the traffic demand. As to the socio-economic factors which represent each subdivided zonal characteristics in Irbid, data on the population and industrial/commercial area are available.

4.046 Fortunately, the following formulae were obtained as the result of correlation analysis with relatively high correlation coefficients.

$$Qpi = 6305 + 0.0019\ Pi + 192\ Ai \qquad (R = 0.74)$$

$$QTi = 1490 + 0.076\ Pi + 18.1\ Ai \qquad (R = 0.80)$$

where Qpi: Total trip ends of passenger cars in zone i (vehicles/day);

QTi: Total trip ends of trucks in zone i (vehicles/day);

Pi: Population in zone i (person);

Ai: Industrial/commercial area (ha);

R: Correlation coefficient.

4.3.5 Forecast of Traffic Demand

4.047 In Chapter 2 of this Report, the population and the built-up area in the City of Irbid as well as the surrounding area, were forecasted for the years of 1985 and 2000. Hence, only the industrial/commercial areas in the future were estimated in this section as the socio-economic factor. The estimation was made on the basis of the following assumptions.

(1) The industrial/commercial area will expand in correlation with the expansion of urbanized area.

(2) It will further increase with the rate of population growth of the city even after full urbanization.

4.048 By employing the relationship between traffic demand and zonal characteristics given above, the intracity traffic demands in Irbid were calculated by zone for the years 1985 and 2000. With regard to intercity traffic, those forecast in the Part II were taken.

4.049 Tables 4.3 and 4.4 show the trip ends related to Irbid and the growth rates respectively.

Table 4.3 Trip Ends in Irbid, 1976, 1985 and 2000

(Unit: Vehicles/day)

Year	Kind of Trips	Passenger Cars	Goods Vehicles	Total
1976	Intracity	30,599	8,601	39,200
	Intercity	14,637	6,206	20,843
	Total	45,236	14,807	60,043
1985	Intracity	40,943	13,636	74,579
	Intercity	28,343	7,895	36,238
	Total	89,286	21,531	110,817
2000	Intracity	86,232	22,522	108,754
	Intercity	38,926	13,058	51,984
	Total	125,158	35,580	160,738

Source: Study Team.

Note: "Irbid" stands for the area covering zones 1 through 6.

Table 4.4 Growth Rates of Trip Ends in Irbid, 1976 to 2000

(Unit: Times)

	Period	
	1976-1985	1976-2000
Passenger Cars	1.97	2.77
Goods Vehicles	1.45	2.40
Total	1.85	2.68

Source: Study Team.

It can be pointed out that the ratio of the intracity traffic to the total trip ends is fairly stable during the estimation period.

4.050 The forecast of the O-D tables in 1985 and 2000 was made by employing a gravity type model and Frater's method on the basis of the existing Table in 1976. The estimated O-D tables are shown in Table 4.5 and Table 4.6.

4.3.6 Traffic Assignment

4.051 The assignment of the future traffic demands estimated above was undertaken for the two alternative road networks, i.e., with the Ring Roads project and without it. The networks were assumed as shown in Figure 4.11, taking account of the consistency with the size of traffic zones. The case without the project is represented by the network without dotted lines. For the traffic assignment, the following formula was employed.

$$P = \frac{1}{1 + T^{d}} + p$$

where P: rate to be assigned;

T: ratio of the operating times on the two shortest alternative routes;

d: constant (= 6);[2/]

p: constant (= 0.05).[2/]

4.052 Each element of the O-D table will be assigned corresponding to the ratio of the average operating times on the most likely two alternative routes.

4.053 Provided that the average speed on the Ring Roads be 60 km/hr and on the other roads be 25 km/hr, the results are obtained as illustrated in Figure 4.12 and Figure 4.13. It is noted from the Figures that the total traffic volume of the two Ring Roads is expected to be about 3,500 to 9,000 vehicles per day at the west section and about 10,000 to 15,000 vehicles per day at the east section in 1985. These traffic volumes are reflecting the fact that the urbanization of Irbid is expanding to the directions of the northeast and southeast. This tendency seems to continue to the future towards 2000, i.e., the growth rate of the traffic volume during the period 1985 to 2000 on the east half ring is forecast at about 80 percent, while that on the west half ring is forecast at only 35 percent.

4.054 The ratio of goods vehicles to total volume is presented in Figure 4.14. It can be said that the ratio would be slightly reduced in the city center with the provision of the Ring Road project.

2/ In all calculation of traffic assignment, these 6 and 0.05 are used.

Table 4.5 Origin-Destination Table for 1985

(Unit: Vehicles/day)

O \ D Zone No.	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
1	0	5,221	6,548	4,638	2,912	8,726	115	868	1,117	446	5,582	1,180	114	37,467
2	5,142	0	1,015	745	452	1,358	26	189	272	110	1,027	533	26	10,895
3	6,495	1,027	0	924	560	1,689	33	270	558	142	1,153	375	33	13,259
4	4,640	760	932	0	419	1,243	22	187	242	98	795	261	24	9,623
5	2,900	799	561	419	0	752	16	127	164	66	534	174	17	6,529
6	8,662	1,371	1,688	1,233	748	0	40	321	418	167	1,370	465	42	16,525
7	97	23	29	20	13	35					1			218
8	846	185	263	189	122	311			2	3	67	94		2,088
9	1,017	250	322	233	148	382	2	5	82	5	1,013	36	7	3,492
10	615	242	190	133	88	225			1		308			1,747
11	3,755	961	1,166	824	542	1,389	2	55	1,024	364	116,205	1,600	1,511	129,400
12	1,138	403	359	246	165	426	2	53	21	6	1,951	2,002	911	7,736
13	105	28	34	21	15	40					2,025	401		2,669
Total	35,412	11,270	13,107	9,615	6,184	16,576	258	2,075	3,901	1,407	132,031	7,121	2,685	241,642

Source: Estimated by the Study Team.

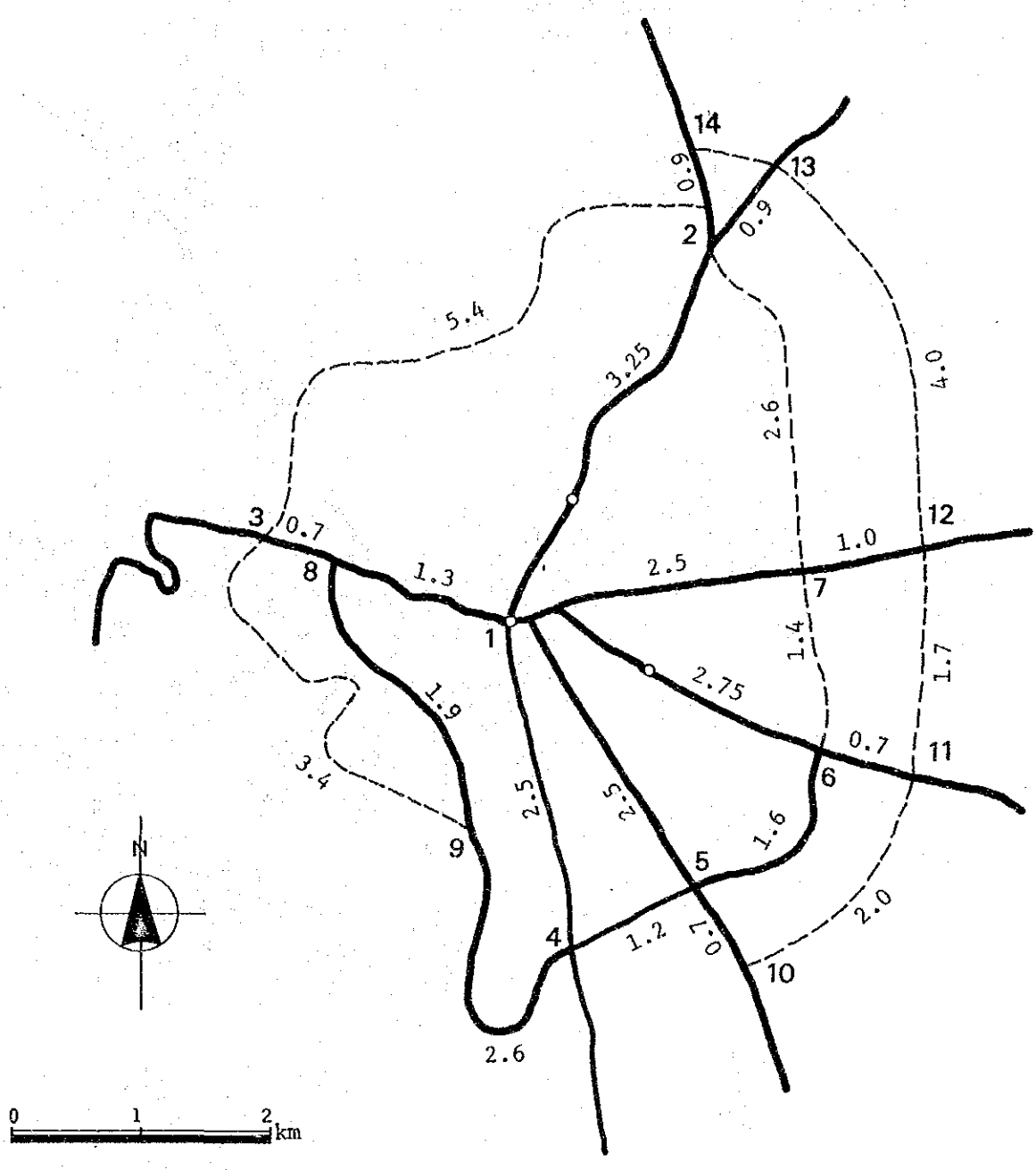
Table 4.6 Origin-Destination Table for 2000

(Unit: Vehicles/day)

Zone No.	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
1	0	7,191	6,685	7,056	3,215	14,831	145	1,096	1,410	559	4,937	1,478	124	48,727
2	7,026	0	1,329	1,473	560	2,842	40	300	439	177	1,833	953	35	17,007
3	6,620	1,357	0	1,346	611	2,631	39	319	616	168	1,461	472	40	15,680
4	7,033	1,501	1,349	0	574	2,921	38	333	577	173	1,522	465	35	16,521
5	3,152	928	601	566	0	1,099	17	140	180	72	630	190	15	7,590
6	14,737	2,882	2,629	2,899	1,110	0	78	620	795	314	2,784	875	70	29,793
7	124	35	34	34	14	70					2			313
8	1,065	290	308	333	136	605			4	4	98	127		2,970
9	1,285	407	382	401	168	722	4	9	120	7	1,559	54	11	5,129
10	767	234	222	230	98	432			2		491			2,476
11	5,015	1,641	1,450	1,536	640	2,842	4	83	1,557	575	198,277	2,471	2,185	218,276
12	1,418	697	418	432	184	799	4	72	30	8	3,062	2,845	1,308	11,277
13	119	42	38	37	28	69					2,995	534		3,862
Total	48,361	17,205	15,445	16,343	7,338	29,863	369	2,972	5,730	2,057	219,651	10,464	3,820	379,621

Source: Estimated by the Study Team.

Figure 4.11 Road Network for Traffic Assignment, Irbid



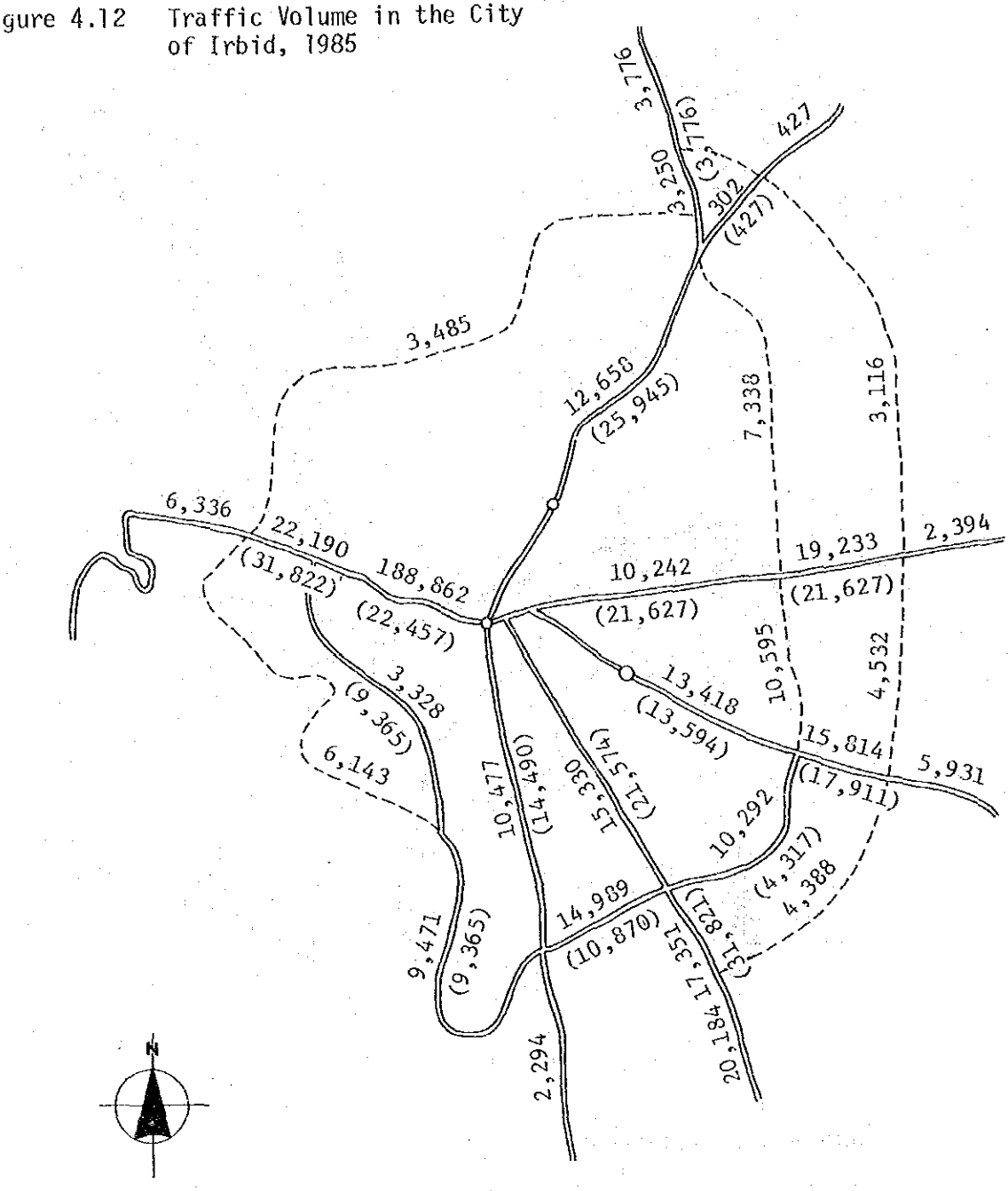
Scale 1:50,000

Legend

4.1	Length of the Link (km)
5	Node Number
———	Network without the Project
- - - - -	Network with the Project

Source: Study Team.

Figure 4.12 Traffic Volume in the City of Irbid, 1985



Legend

Existing Road

Ring Road

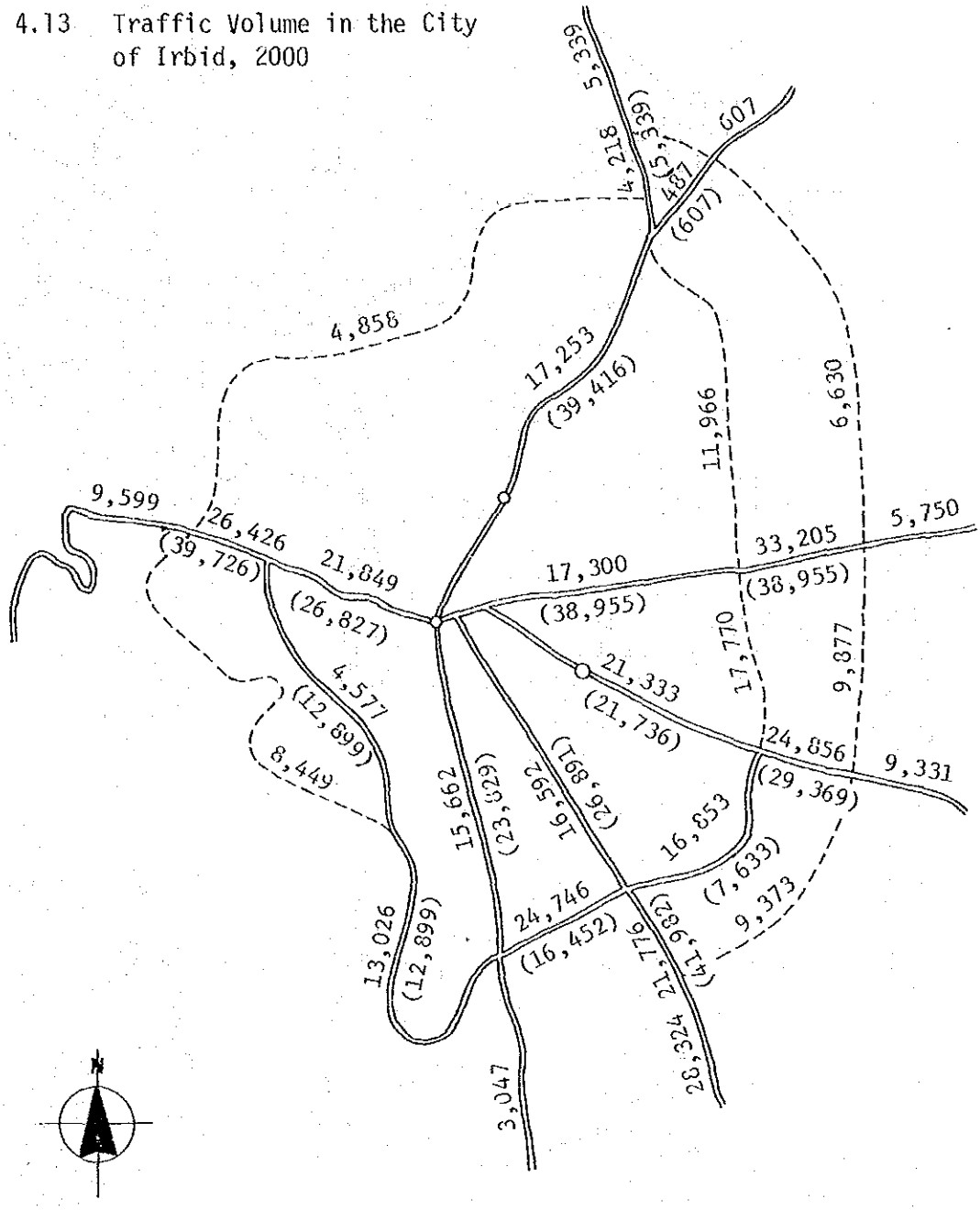
14,989 Volume with Project (vehicles)

(10,870) Volume without Project (")

Scale 1:50,000

Source: Study Team.

Figure 4.13 Traffic Volume in the City of Irbid, 2000



Legend

═══ Existing Road

- - - - - - Ring Road

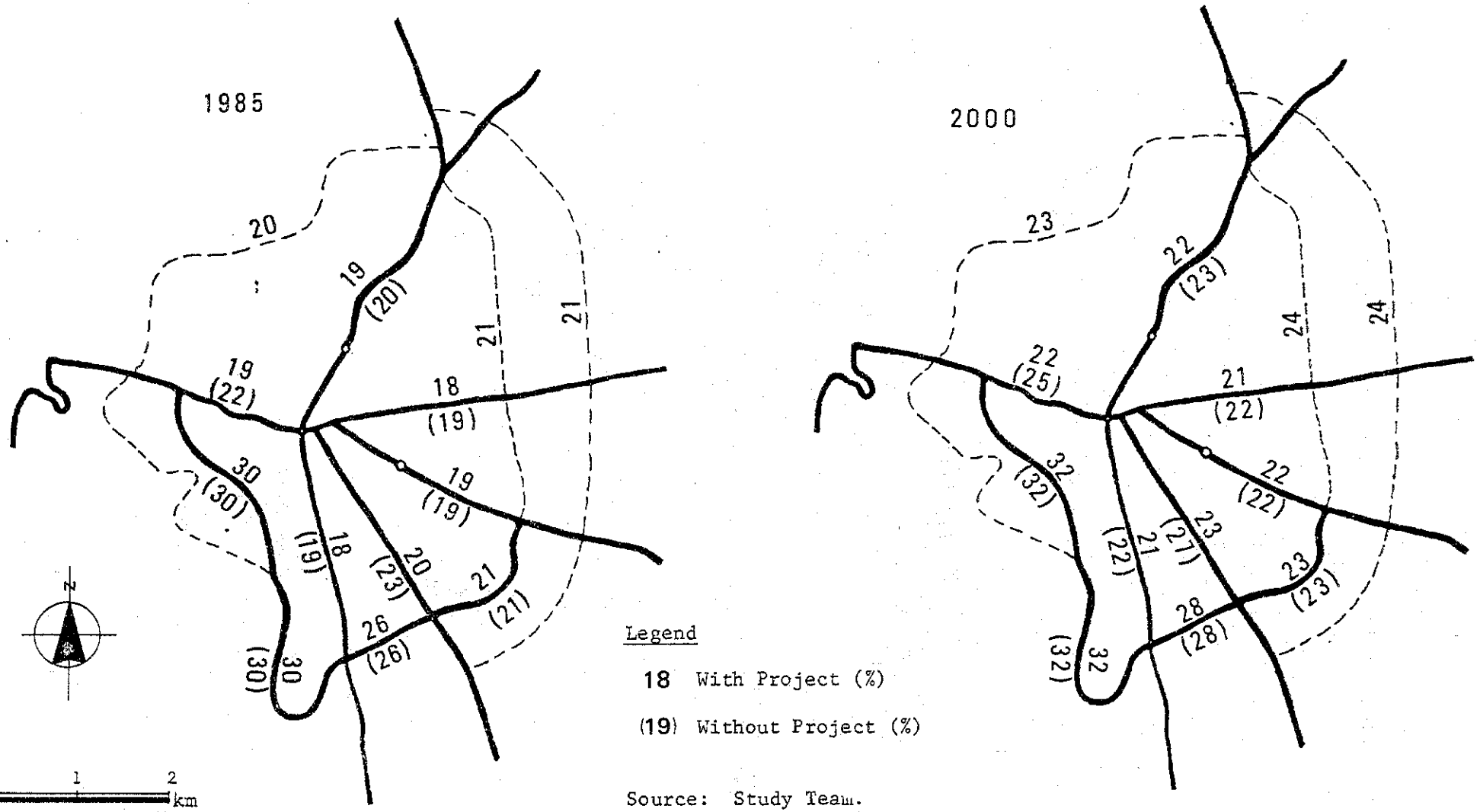
24,746 Volume with Project (vehicles)

(16,452) Volume without Project (")

Scale 1:50,000

Source: Study Team.

Figure 4.14 Ratio of Goods Vehicles to Total Vehicles in the City of Irbid, 1985 and 2000



Legend

18 With Project (%)

(19) Without Project (%)

Source: Study Team.

4.055 Table 4.7 shows the composition of traffic at each link in terms of intracity, intercity and through-traffic. The table indicates that a large portion of the long-distance trips, such as represented by through-traffic and intercity traffic, would be attracted to the Ring Roads from the existing road as a consequence of the completion of the project.

4.056 From the results above, the followings are pointed out as the effects of the Ring Roads project in terms of traffic flows.

(1) The traffic congestion in the center of the city will be drastically reduced.

(2) Not only through-traffic but also related traffic making long-distance trips will be able to save great amounts of operating time by by-passing the central business district.

(3) The Ring Roads will contribute a great deal to the social and economic development of the surrounding areas, which are relatively isolated and less developed at present, by providing an effective transport facility.

4.4 Network Study

4.4.1 General

4.057 The road network in Irbid was investigated in terms of the following two points. One is whether or not the network is sufficient to enable a smooth traffic flow to take place in the future as well as at present. This analysis is done by examining whether or not each link is effectively connected to each other. The other aspect is the comparison of traffic demand and road capacities. This is based on the idea that roads should have adequate capacities to satisfy the traffic demands. Hence, the capacities of all the roads, including planned roads, will be compared with the traffic demand for the years 1985 and 2000. For this purpose, the ongoing road projects are identified first.

4.4.2 Ongoing Projects

4.058 Figure 4.15 shows the ongoing projects in Iribd. The roads under construction are as follows:

(1) Inner Ring: 3.5 km at the east part of the Ring, with two lanes;

Table 4.7 Composition of Traffic in the City of Irbid, 1985 and 2000

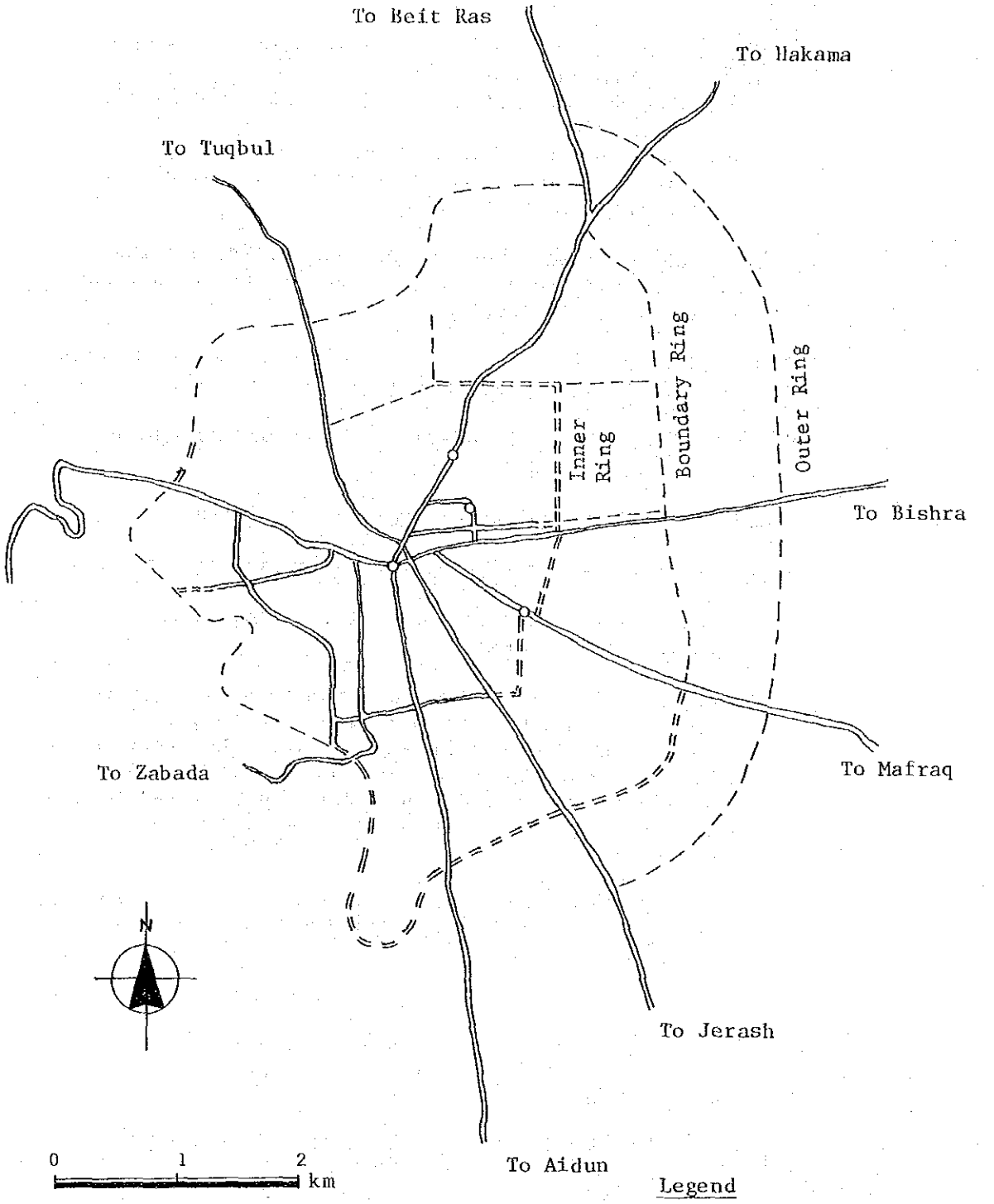
(Unit: percent)

Link[1]	1985						2000					
	With Project			Without Project			With Project			Without Project		
	Intra	Inter	Through	Intra	Inter	Through	Intra	Inter	Through	Intra	Inter	Through
Radial Roads												
1-2	83.1	16.9	0.0	69.0	30.0	1.0	84.0	16.0	0.0	68.7	30.4	1.0
2-14	83.1	16.9	0.0	69.0	30.0	1.0	84.0	16.0	0.0	68.7	30.4	1.0
2-13	83.1	16.9	0.0	69.0	30.0	1.0	84.0	16.0	0.0	68.7	30.4	1.0
1-7	95.4	4.6	0.0	70.0	30.0	0.0	95.0	5.0	0.0	67.7	32.3	0.0
7-12	95.4	4.6	0.0	70.0	30.0	0.0	95.0	5.0	0.0	67.7	32.3	0.0
1-6	79.4	20.5	0.1	76.4	22.5	1.1	84.0	16.0	0.0	73.6	26.4	0.0
6-11	79.4	20.5	0.1	76.4	22.5	1.1	84.0	16.0	0.0	73.6	26.4	0.0
1-5	38.3	61.7	0.0	33.0	60.0	7.0	39.0	61.0	0.0	29.6	62.6	7.8
5-10	38.3	61.7	0.0	33.0	60.0	7.0	39.0	61.0	0.0	29.6	62.6	7.8
1-4	89.4	10.6	0.0	75.0	25.0	0.0	91.0	9.0	0.0	75.2	24.8	0.0
1-8	85.3	14.7	0.0	67.4	26.0	6.6	83.0	17.0	0.0	63.3	28.6	8.1
8-3	85.3	14.7	0.0	67.4	26.0	6.6	83.0	17.0	0.0	63.3	28.6	8.1
Ring Roads												
2-3	58.6	41.4	0.0	-	-	-	55.0	44.0	1.0	-	-	-
3-9	35.0	43.0	22.0	-	-	-	34.0	41.0	25.0	-	-	-
9-4	35.0	43.0	22.0	67.4	26.0	6.6	34.0	41.0	25.0	34.0	41.0	25.0
4-5	41.3	44.7	14.0	41.3	44.7	14.0	46.0	41.0	13.0	46.0	41.0	13.0
5-6	47.1	51.7	1.2	47.1	51.7	1.2	49.0	50.0	1.0	49.0	50.0	1.0
6-7	45.7	52.5	1.8	-	-	-	46.0	52.0	2.0	-	-	-
7-2	51.0	46.4	2.6	-	-	-	53.0	45.0	2.0	-	-	-
8-9	35.0	43.0	22.0	-	-	-	34.0	41.0	25.0	-	-	-
10-11	47.1	51.7	1.2	-	-	-	46.0	41.0	13.0	-	-	-
11-12	45.7	52.5	1.8	-	-	-	46.0	52.0	2.0	-	-	-
12-14	45.7	52.5	1.8	-	-	-	53.0	45.0	2.0	-	-	-

Source: Study Team.

Note: 1/ Numbers indicate Node Numbers in Figure 4.11.

Figure 4.15 Ongoing Project in the City of Irbid, 1979



Scale 1:50,000

Source: Irbid Municipality.

(2) Boundary Ring: 5.5 km at the south part of the Ring, with two lanes which will be widened to four lanes, and 0.4 km at west part of the Ring, with two lanes;

(3) Route 11 to Jerash: The section between the Inner Ring and Route 15 is partly under construction for widening from two lanes to four lanes;

(4) Route 23 to Aidun: Part of the section between the Inner Ring and Aidun is under construction for widening from two lanes to four lanes;

(5) Radial Road to the Inner Ring: About 300 m on the road along the Bishra street, with two lanes; and

(6) Radial Road to the Boundary Ring: About 400 m of a radial road to the west.

The roads planned by the Municipality of Irbid are as follows:

(1) Inner Ring: About 1 km at the north part of the Ring;

(2) Boundary Ring: The remainder of the Ring which is approximately 12.3 km;

(3) Radial Road Between Inner and Boundary Ring: Two roads at the east of the Inner Ring, one is a road of 1 km in the length near the industrial area, the other is the extension of the road along Bishra street. Also a road to the north from the Inner Ring is planned, terminating half way between the Inner Ring and the Boundary Ring;

(4) Route 23 to Beit Ras: The section between the Inner Ring and the Boundary Ring will be widened from two lanes to four lanes.

4.4.3 Road Network Recommended

a. Network for 1985

4.059 Taking into account the smooth connection of each link and the traffic demand expected for 1985, which is shown in Figure 4.12, the following results were obtained.

(1) Inner Ring:

The east part of the ring which is now under construction should be completed and have two lanes. The Inner Ring, planned by the Municipality, is not smoothly

linked at the intersection of Route 16 to Mafraq. It is recommended to shift the section slightly eastward, to avoid complicated traffic movement.

(2) Boundary Ring:

The whole ring should be completed and have two lanes. However, the section between Route 11 to Jerash and Route 23 to Aidun needs to have four lanes. In addition, in the case that the Outer Ring is not implemented, the east part of the ring between Route 11 to Jerash and Route 23 to Beit Ras should be a four-lane road. A study on this issue will be made from the economic viewpoint in a subsequent section of this chapter. But, in any case, sufficient width of land for four lanes should be acquired at the outset.

(3) Outer Ring:

In the case that the Boundary Ring has only two lanes, the Outer Ring should be completed with two lanes. The Ring should be the half ring between Route 11 to Jerash and Route 23 to Beit Ras.

(4) The Road Between the Boundary Ring and the Outer Ring:

This construction aims to support the development of the existing industrial area and the candidate site of the Industrial Estate project. The width of two lanes will be sufficient for the demand.

(5) The Road Between the Boundary Ring and Bishra:

The existing road to Bishra is too narrow to form a part of a trunk road network in Irbid and is difficult to be widened in the CBD area. Therefore, it is proposed to extend the existing broad road, which is about 50 m north of Bishra Street, in parallel.

This construction of a new road between the Inner Ring and the Boundary Ring will be more effective if an industrial estate is built along the new road.

The width should be four lanes for the section between the Inner and the Boundary Rings and two lanes between the Boundary and the Outer Rings.

This road should be further extended to Ramtha via Bishra in accordance with the city expansion.

(6) Improvement of Route 23:

Route 23 is the most important arterial road to the north from Irbid. The section of about 12 km between the Boundary Ring and the Inner Ring should be widened at the earliest possible time.

(7) New Connecting Road of Route 16 from Jordan Valley to the West Part of the Boundary Ring:

Route 16 from Jordan Valley to Irbid City has 1) sharp turning at the Wadi Zabada, 2) steep slope to go up from Wadi Zabada to Irbid City and 3) another sharp turning at the entrance of Irbid City. So, it is proposed by city officials to construct a new connecting road from the point of Route 16 crossing the bottom of the Wadi Zabada to some point of Boundary Ring coming close to the Wadi Zabada. Based on our traffic projection, it is not necessary to construct this new connecting road, since the traffic volume in 1985 on this part of Route 16 is estimated to be within the capacity of the existing road. However, there are many large trucks from Jordan Valley and vehicles including these trucks have difficulty and are experiencing danger in driving this part of Route 16. Thus, for the sole purpose of 1) alleviating dangers experienced by drivers, 2) providing better alignment and better gradient and 3) up-grading the service level to traffics going south through Irbid City, it seems to be reasonable to construct the new connecting road. In this connection, one condition remains to be noted. Even though the new connecting road be constructed, the existing Route 16 should be maintained and be given for service, since it has better access to the city center than the new connecting road.

b. Network for 2000

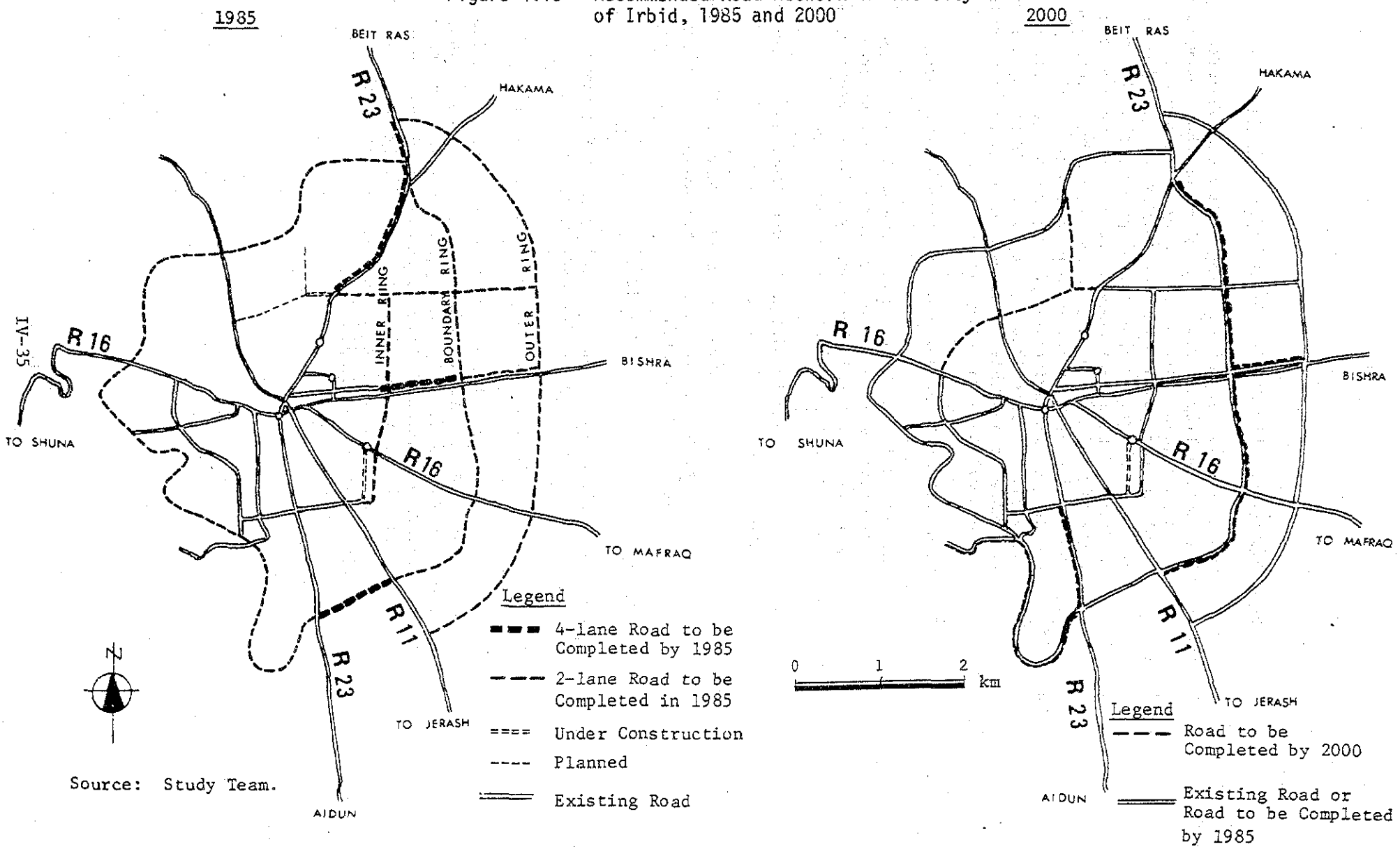
4.060 At the earliest date in the year 2000 or toward the end of 1999, the followings are recommended to be developed, as shown in Figure 4.16.

(1) Widening of the Boundary Ring:

The Boundary Ring should be widened to four lanes at the following sections:

1) the east part between Route 11 to Jerash and Route 23 to Beit Ras; and
2) the south part between Route 23 to Aidun and Zabada Street.

Figure 4.16 Recommended Road Network in the City of Irbid, 1985 and 2000



Source: Study Team.

(2) Completion of the Inner Ring:

The northwest part of the ring should be completed. The Municipality of Irbid has given up the construction of the northwest part of the Inner Ring, since it requires vast amount of compensation for the removal of people now residing on the proposed right-of-way. The lack of this section will force the users of the Inner Ring to make a long detour or to drive into the CBD. Therefore, it could be proposed to complete the Ring by improving two of the existing streets and using each of them as a one-way road. This improvement will make it possible to reduce the compensation costs in comparison to the original plan.

(3) Road Between Inner and Boundary Ring at the North:

The construction of the road between the two rings at the north will be effective for mitigating the concentration of Beit Ras-bound traffic on Route 23 to as well as better utilization of the rings.

(4) Widening of Road to Bishra Between Boundary and Outer Rings:

The new road to Bishra should be widened to four lanes between the Boundary and the Outer Rings to satisfy the expected traffic demand.

(5) Widening of Route 23 to Aidun:

Route 23 to Aidun should be widened to four lanes between the Inner and Boundary Rings.

(6) The Road to Zabada:

Residential facilities are to be constructed in the east area of Zabada, which has been annexed to the Municipality of Irbid this year. The existing road to Zabada is narrow and partly unpaved, and therefore should be improved. The length to be improved is about 1.5 km. This road might be developed so as to connect it with Route 16 in the future.

4.4.4 Formulation of Alternatives for Boundary and Outer Rings

4.061 Figure 4.17 shows the roads for which an economic pre-feasibility study are to be undertaken later. They are as follows:

(1) Rest of the Boundary Ring:

The part for which construction has not yet started by the Municipality. It is partitioned as follows:

1) Section A: between Route 16 to Mafraq and Route 23 to Beit Ras;

2) Section B: between Route 23 to Beit Ras and Route 16 to Shuna;

3) Section C: between Route 16 to Shuna and Zabada Street.

(2) Outer Ring Road:

The length will be 7.7 km in total.

(3) Two Roads Connecting the Boundary Ring and the Outer Ring:

Both lengths being about 1.0 km, they are:

1) A: connecting road near the existing industrial area;
2) B: connecting road along Bishra Street.

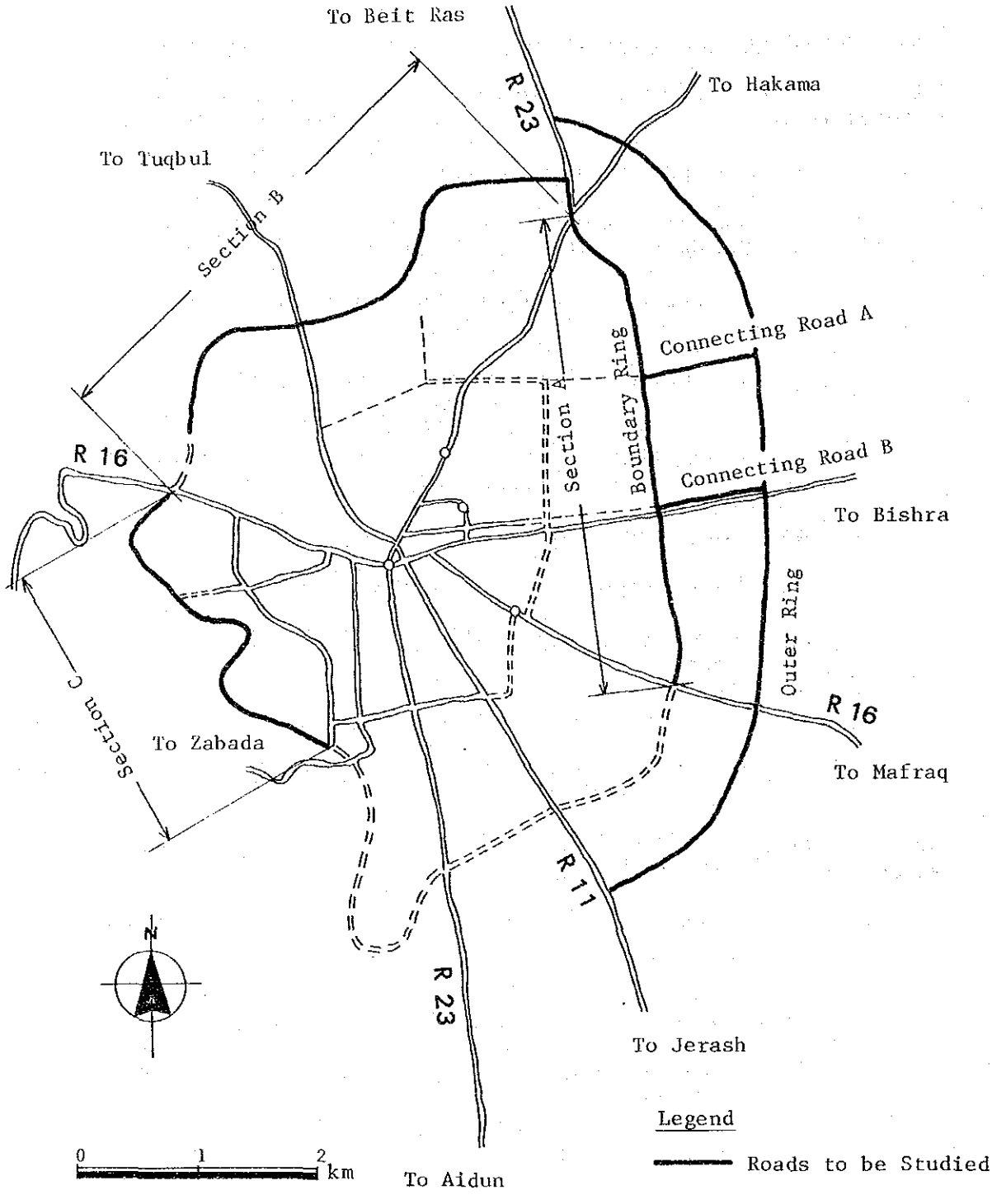
4.062 Prior to determining the alternatives for the subsequent study, the following assumptions were made.

(1) All the roads under construction should be completed by 1985;

(2) Out of that portion of the Boundary Ring now under construction, only the section between Route 11 to Jerash and Route 23 to Aidun will have four lanes, while the other part will have only two lanes by 1985; and

(3) By 2000, the southwest part of the Boundary Ring now under construction will be widened to four lanes.

Figure 4.17 Roads to be Studied in the City of Irbid



Scale 1:50,000

Source: Study Team.

4.5 Preliminary Design

4.5.1 General

4.063 The purpose of preliminary design is to make alignment plans which are suited to the needs of the increase in traffic volume envisaged for the future, such increase being due to greater interregional and intracity economic activities relating to the expansion of urbanized area. It will be essential for the Study to estimate the effects of the proposed project on the traffic volume and traffic pattern within the framework of the total planning of alignment in the Irbid Municipality.

4.064 On the technical side of the project, we have to be sure that alternatives are adequately considered and the correct technical solution is found. Key points which must be investigated are that the width of the road, location of the road, and the length of the road are appropriate to the traffic.

4.5.2 Design Standards

a. Traffic Capacity and Number of Lanes in Each Road

4.065 The Study Team conducted the traffic capacity analysis, using the traffic volumes predicted for the target years as described in Section 4.3. The concepts and methodology used for the traffic capacity analysis are based on the "Highway Capacity Manual," of Highway Research Board USA. However, some adjustment was made to reflect local conditions, based on the result of studies accomplished by the Highway Research Board, Japan.

4.066 Traffic capacities at the uninterrupted flow level under ideal conditions are summarized in Table 4.8. Taking account of the traffic capacities and forecasted traffic volume, the number of lanes in each road was decided as shown in Table 4.10 which appears later.

b. Geometric Design Standards

4.067 "Master Road Plan 1978-1982", which includes the "Road Design Standards", was published by the Hashemite Kingdom of Jordan in September, 1978. These standard specifications must be applied to newly planned rural highways in Jordan. However, since the Ring Roads are located in a proposed urban area, the above mentioned standards need to be modified to meet the more precise requirements of an urban roadway.

4.068 Taking into account the above factors, we made an adjustment in the main items of design criteria to be used for the Ring Roads by referring to the Japanese urban "Road Structure Ordinance".

Table 4.8 Design Traffic Capacity Analysis

ITEM	DESIGN SPEED KM/HR	LANE WIDTH (m)	LATERAL CLEARANCE		HEAVY VEHICLE		COEFFICIENT OF ADJUSTMENT					BASIC CAPACITY (P.C.U/HR)	POSSIBLE CAPACITY (VEH/HR)	DESIGN LEVEL	ADJUSMENT OF DESIGN LEVEL	DESIGN CAPACITY (VEH/HR)	PEAK FACTOR (%)	RATE OF DIRECTION (%)	DESIGN DAILY VOLUME (VEH/DAY) PER LANE	REMARKS
			LEFT	RIGHT	% OF H.V.	PASSENGER CAR EQUIVALENT	LANE WIDTH	LATERAL CLEARANCE	HEAVY VEH.	CONDITION OF SIGHT	TOTAL									
			(m)	(m)	P_T	E_T	γ_L	γ_C	γ_T	γ_I		C_B	C			C_D	K	D	ADT	
2-Lane, 1-Way (Proposed)	60	3.3	0.5	0.75	5.8	2.8	0.95	0.77	0.90	0.75	0.494	2200	1087	2	0.9	978	7.5	55	11500	Per 1-lane
2-Lane, 2-Way (Proposed)	60	3.3	0.5	0.5	5.8	3.2	0.95	0.75	0.89	0.75	0.476	2200	1047	2	0.9	942	7.5	55	12500	Per 2-lane
2-Lane, 1-Way (Existing)	60	3.3	0.5	0.5	5.4	2.8	0.95	0.75	0.90	0.7	0.449	2200	988	2	1.0	988	7.5	55	12000	Per 1-lane
2-Lane, 2-Way (Existing)	40	3.3	0.5	0.5	5.4	3.2	0.95	0.75	0.90	0.7	0.449	2200	988	2	1.0	988	7.5	55	13000	Per 2-lane

$$\gamma_T = \frac{100}{100 - P_T + E_T \cdot P_T}$$

$$C = C_B \cdot \gamma_L \cdot \gamma_C \cdot \gamma_I \cdot \gamma_T$$

ADT (MULTIPLE LANES)

$$= \frac{5000 \cdot C_D}{K \cdot D}$$

WHERE

γ_T : COEFFICIENT OF ADJUSTMENT FOR HEAVY VEHICLES.

P_T : PERCENTAGE OF HEAVY VECHICLES.

E_T : PASSENGER CAR EQUIVALENT OF HEAVY VECHILES.

γ_L : COEFFICIENT OF ADJUSMENT FOR LANE WIDTH.

γ_C : COEFFICIENT OF ADJUSMENT FOR LATERAL CLEARANCE.

γ_I : COEFFICIENT OF ADJUSTMENT FOR CONDITION OF SIGHT.

K : PEAK FACTOR (%).

D : RATE OF DIRECTION (%).

C_D : DESIGN CAPACITY (VEH/HOUR)

C_B : BASIS CAPACITY (P.C.U/Hr)

Source: Highway Research Board, USA, "Highway Capacity Manual", Highway Research Board, Japan.

4.069 The typical cross-sections and main items of the design standards for Ring Roads are illustrated in Figure 4.18 and described in Table 4.9.

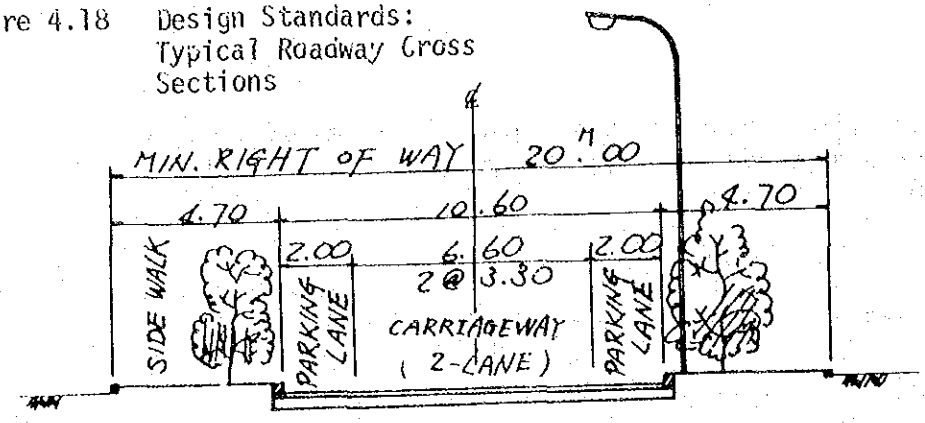
Table 4.9 Roadway Geometric Design Standards

Item	Unit	Recommended Standards
Design Speed	km/h	60
R.O.W. Width	m	30 (4-lane), 20 (2-lane)
Lane Width	m	3.3
Parking Lane Width	m	2.00
Side Strip	m	0.25
Medial Strip	m	2.90
Crossfall of Carriageway	%	2.0
Type of Pavement	-	Asphalt Concrete
Maximum Superelevation	%	10.0
Maximum Radii	m	120
Maximum Gradient	%	5 or 7*
Stopping Sight Distance	m	75
Minimum Vertical Curve Length	m	50
Minimum Horizontal Curve Length	m	100 or 700/θ
Minimum Transition Curve Length	m	50
Minimum Parameter of Clothoid Curve	m	100

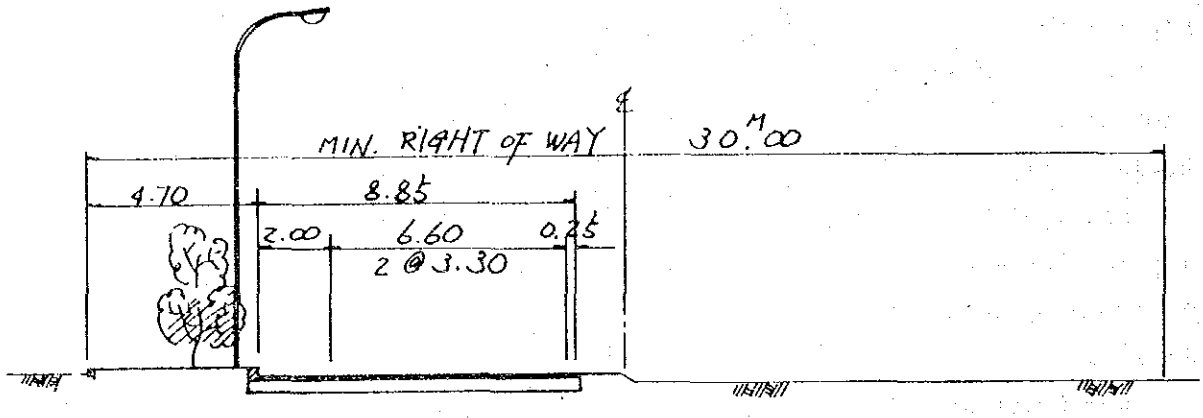
Source: Study Team.

Notes: 1. The figure with asterisk shows value of absolute maximum.
2. θ shows intersection angle for horizontal curve.

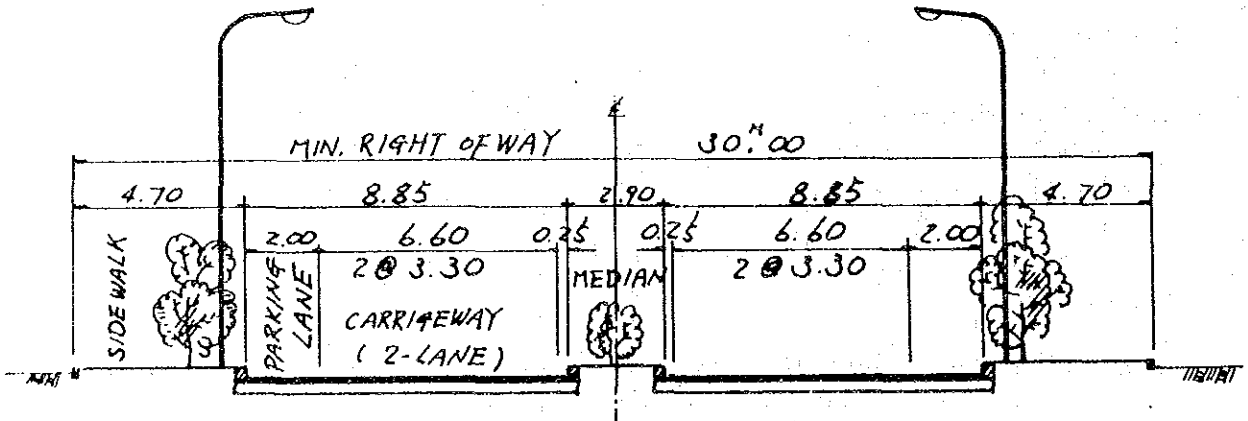
Figure 4.18 Design Standards: Typical Roadway Cross Sections



2-Lane 2-Way for Boundary Ring Road (4.0 - 12.67 km)
Outer Ring Road (0 - 7.7 km)
Connecting Road A

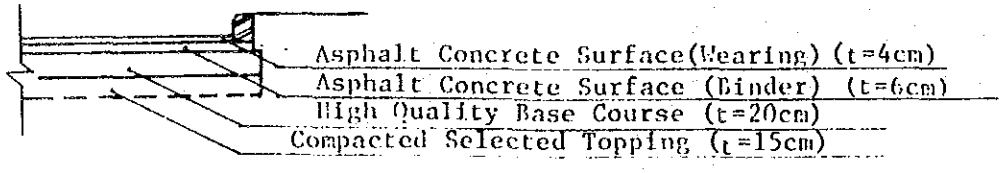


2-Lane 2-Way for 1st Stage (1985) of Boundary Ring Road (0 - 4.0 km)
Connecting Road B

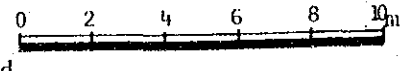


4-Lane 2-Way for Ultimate Stage (1990) of Boundary Ring Road (0 - 4.0 km)
Connecting Road B

Details of Pavement



Source: Study Team.



Note: In cost estimation, roadside trees are excluded.

4.5.3 Restatement of Alternatives

4.070 The alternative plans to be studied in terms of economic feasibility were identified in Table 4.10.

Table 4.10 Alternatives in Terms of Number of Lanes, 1985, 1990 and 2005

Roads Connected	Alternative I			Alternative II		
	1985	1990	2005	1985	1990	2005
Boundary Ring						
Section A	2 lanes	4 lanes	4 lanes	4 lanes	4 lanes	4 lanes
Section B & C	2	2	2	2	2	2
Outer Ring	2	2	2	0	0	0
Connecting Road						
A	2	2	2	2	2	2
B	2	4	4	0	0	0

Source: Study Team.

The main difference of the two alternatives depends on whether or not the Outer Ring is constructed. The number of lanes at each section were determined on the basis that the road capacity would be sufficient for the traffic demand in any year.

4.5.4 Alignment Description for Preliminary Study

4.071 An alignment study of the Boundary Ring, Outer Ring and the Connecting Roads was conducted to examine design standards and determine the number of lanes, shown in Figure 4.19.

a. Boundary Ring Road

4.072 Boundary Ring Road has a radius of 2.3 km from the Irbid City center. It consists of three sections and is 12.3 km long, excluding the southern part and part of the western part where it crosses the wadi.

(1) Section A (0.0 to 4.0 km):
Between Route 16 to Mafraq and Route 23 to Beit Ras.

Two lanes are to open in 1985, and four lanes are to be open in 1990. This section runs across the flat part of eastern Irbid, and therefore, only a small amount of earthwork is required, reducing the construction cost per unit area.

(2) Section B (4.0 to 8.9 km):
Between Route 23 to Beit Ras and Route 16.

Two lanes open in 1985. This section passes along a small wadi in the northern part and acrosses the existing residential area at the 8.0 to 8.9 km portion of the road station point as shown by distance markings in Figure 4.19. The success of the road construction effort will depend on the acquisition of that residential land.

(3) Section C (9.27 to 12.67 km):
Between Route 16 to Shuna and Zabada Street.

Two lanes open in 1985. This section runs across the western part of Irbid City, forming a slant along the wadi, and will have a high construction cost per unit area due to the costs of the large amount of earthworks, stone masonry and construction of a bridge.

b. Outer Ring Road

4.073 The Outer Ring Road forms a semicircle totalling 7.7 km in length. It runs across the flat part of eastern Irbid between Route 16 and 23, being 0.7 to 1.0 km from the Boundary Ring Road, and will be of a lower construction cost. The road will open in 1985 with two lanes.

c. Two Connecting Roads

4.074 These are the two roads connecting the Boundary Ring and the Outer Ring Roads being of 1.0 km length respectively.

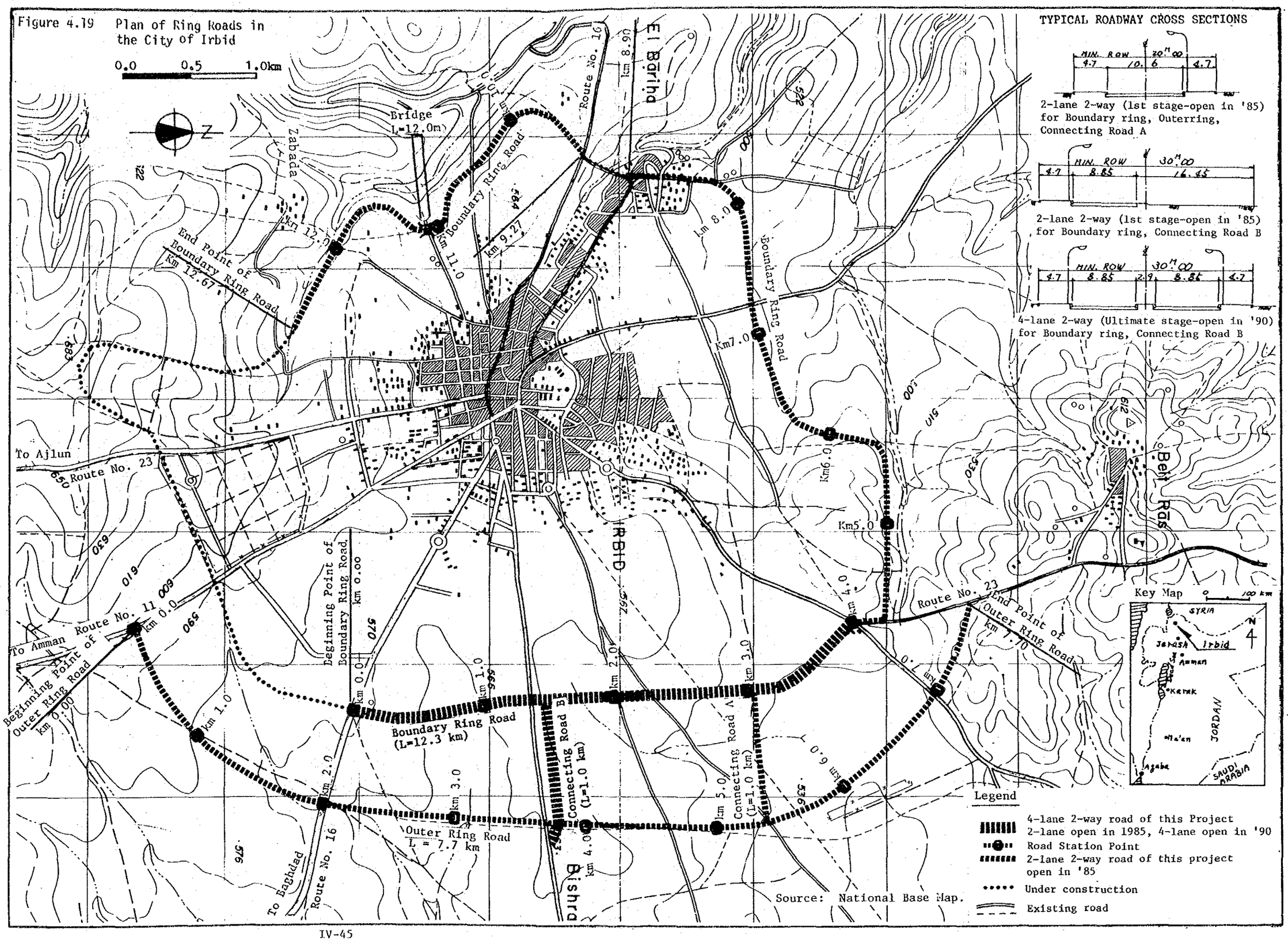
(1) Connecting Road A:

Two lanes open in 1985. Near the existing industrial area.

(2) Connecting Road B:

Two lanes open in 1985 and four lanes open in 1990. Along Bishra Street.

Figure 4.19 Plan of Ring Roads in the City of Irbid



TYPICAL ROADWAY CROSS SECTIONS

2-lane 2-way (1st stage-open in '85) for Boundary ring, Outerring, Connecting Road A

2-lane 2-way (1st stage-open in '85) for Boundary ring, Connecting Road B

4-lane 2-way (Ultimate stage-open in '90) for Boundary ring, Connecting Road B

Legend

- 4-lane 2-way road of this Project
- 2-lane open in 1985, 4-lane open in '90
- Road Station Point
- 2-lane 2-way road of this project open in '85
- Under construction
- Existing road

Source: National Base Map.

4.5.5 Preliminary Design

a. Basic Objectives

4.075 The rough preliminary design was carried out with heed paid to the following basic objectives.

(1) To meet the design standards set out in Section 4.5.2;

(2) To leave sufficient allowance in the designs of the horizontal and vertical alignment to meet possible minor deviations in the next stage of design;

(3) To minimize separation or severance of existing communities; and

(4) To minimize the length of embankment section to reduce the construction cost and enhance the amenities of the city.

b. At-grade Intersection Design

4.076 At intersections of the Ring Roads and main roads, it was recommended that traffic signals be installed instead of rotary-type intersections, taking account of the traffic volume, traffic congestion and accident rate. The number of the intersections to be controlled by signals in each road is presented below.

Boundary Ring Road	8 places
Outer Ring Road	4
Connecting Road A	1
Connecting Road B	1

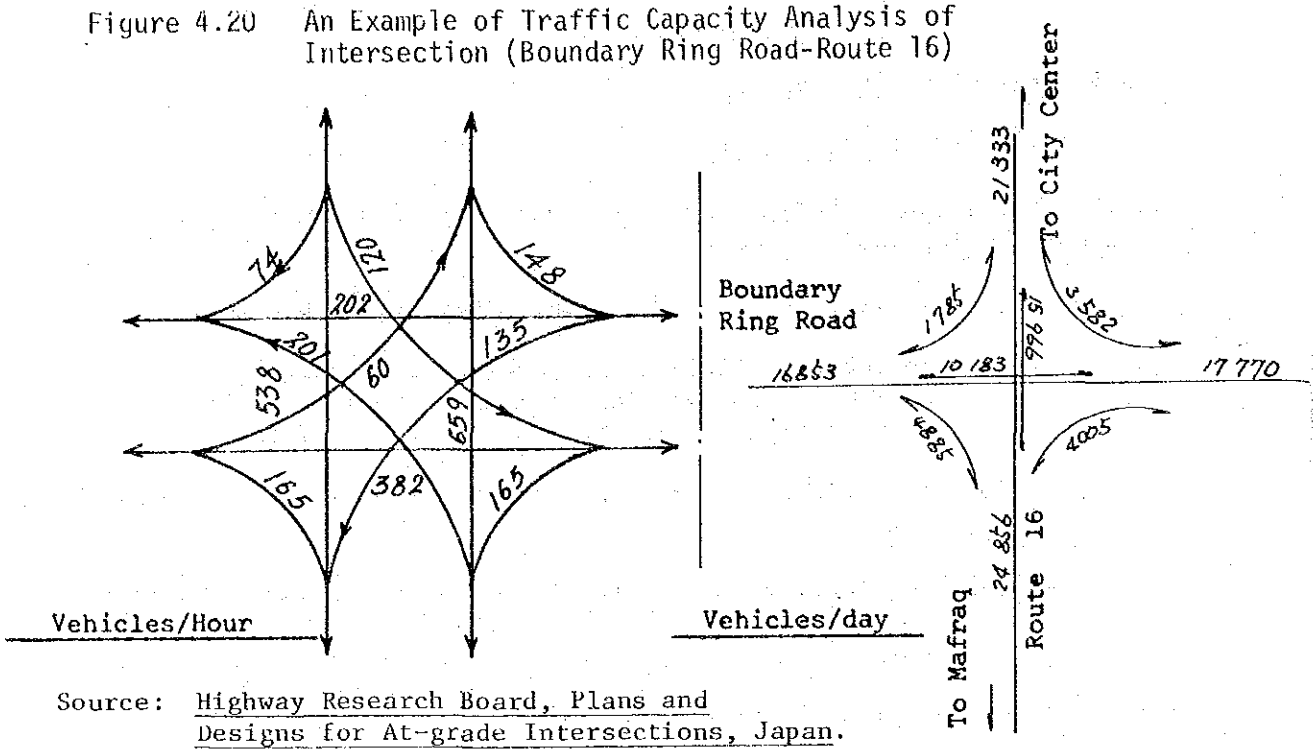
4.077 Capacity analysis is one of the most important considerations in the design of signal controlled intersections. An example of the calculations of the capacity at intersections and the procedure adopted is shown in Figure 4.20 and Table 4.11 in accordance with the procedures in "Highway Research Board, Plans and Designs for At-grade Intersections, Japan".

4.078 Typical drawings of the at-grade intersection are shown in Figure 4.21 as the result of traffic capacity analysis.

c. Pavement Design

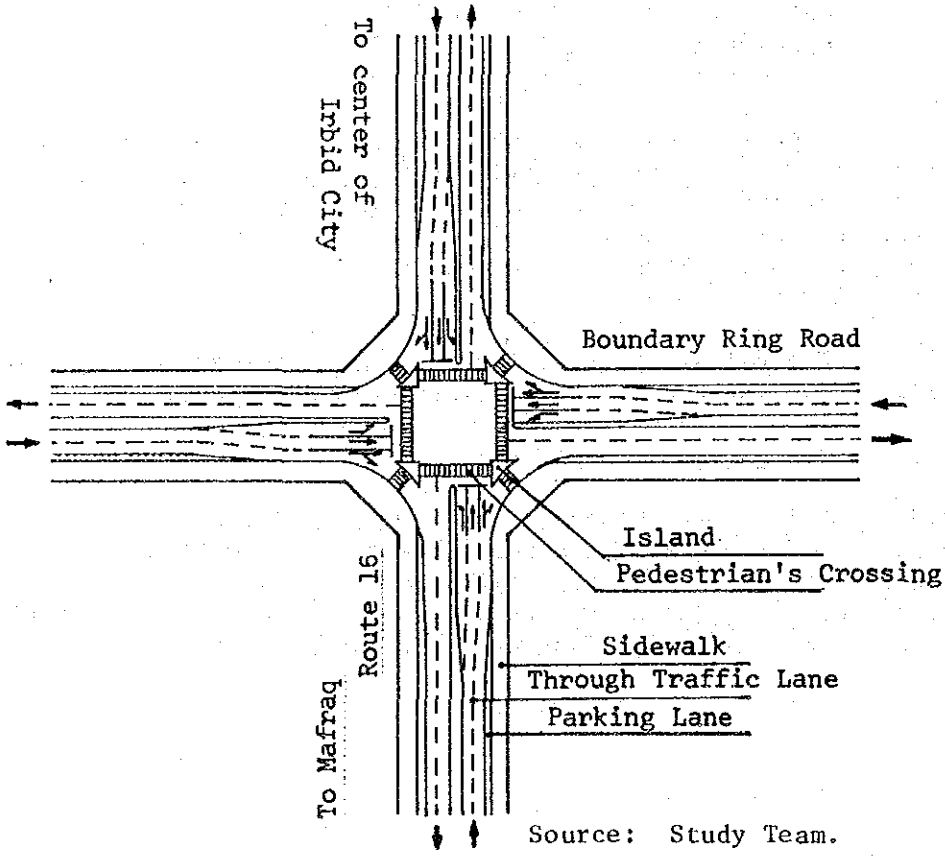
4.079 The design method for the flexible pavement structure recommended for the Ring Roads project is based on the "AASHO Interim Guide for Design of Pavement Structures, 1972". The elements of design used in the AASHO method are daily traffic volume, serviceability of the pavement, values of soil support and the regional factor.

Figure 4.20 An Example of Traffic Capacity Analysis of Intersection (Boundary Ring Road-Route 16)



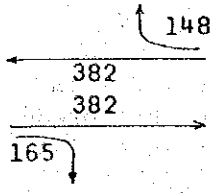
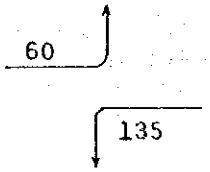
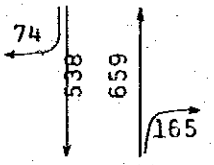
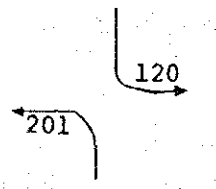
Source: Highway Research Board, Plans and Designs for At-grade Intersections, Japan.

Figure 4.21 At-grade Intersection Drawings (Boundary Ring Road-Route 16)



Source: Study Team.

Table 4.11 An Example of Traffic Capacity Analysis of Intersection[1/] (Boundary Ring Road – Route 16)

Traffic Phase (veh/hr)		Traffic Volume V [2/] (veh/hr)	Possible Capacity Cp (veh/hr)		Integrated Congestion Ration Y= V/Cp	Modified Y Y! (%)	Phase Time (sec)
1		VR = 148) 530 VT = 382)(28%)	1200x0.954x1 = 1800x0.954x1 =	2800	0.189	25%	20+2sec
		VT = 382) 547 VR = 165)(30%)	1800x0.954x1 = 1200x0.954x1 =	2800	0.195		
2		VL = 60	1200x0.954x1 =	1100	0.055	15%	12+2sec
		VL = 135	1200x0.954x1 =	1100	0.123		
3		VR = 74) 612 VT = 538)(14%)	1200x0.954x1 = 1800x0.954x1 =	2800	0.219	37%	30+2sec
		VR = 165) 824 VT = 659)(20%)	1200x0.954x1 = 1800x0.954x1 =	2800	0.294		
4		VL = 120	1200x0.954x1 =	1100	0.109	23%	18+2sec
		VL = 201	1200x0.954x1 =	1100	0.183		
Total					0.795	100%	88sec

Source: As in Figure 4.20.

Notes: 1/ Basic elements assumed in this analysis are:
(1) Traffic capacity per lane: through lane = 1,800 pcu/hour
turn lane = 1,200 pcu/hour
(2) Design daily volume: see Figure 4.20
(3) Other elements: peak factor = 7.5%
percent of heavy vehicles = 5.8%
rate of direction at peak hour = 55%

2/ VR: Volume turning right
VT: Volume going through
VL: Volume turning left

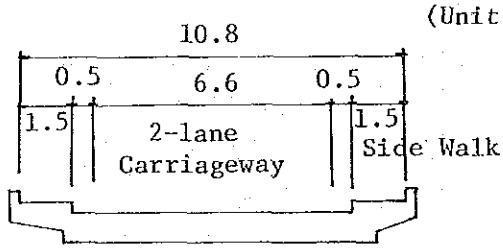
4.080 After making assumptions, calculations, and consideration of examples of recent road construction around Irbid City, the Study Team decided to adopt the pavement thicknesses as shown below.

Asphalt Concrete Surface (Two Layers)	10 cm
Future Overlay of Asphalt Concrete Surface	5-10 cm
High Quality Base Course	20 cm
Compacted Selected Topping	15 cm

d. Bridge Required

4.081 Need for only one bridge was identified, at the 11.05 km point on the Boundary Ring Road. It should be a two-lane reinforced concrete (R.C.) slab bridge and have 12.0 m span. The crosssection is shown below.

(Unit: m)



4.082 The economical span of R.C. slab bridge is 10 to 17 m. It will be built by cast-in place methods. This type of bridge is the most economical compared to other types.

e. Lighting

4.083 The objective of providing lighting facilities is to reduce the number of traffic accidents occuring during the hours of low light levels and darkness. The average intensities of illumination used in the design of the installations are 10 lux. The use of the low pressure sodium lamp for the light source is recommended for the following reasons:

(1) High efficiency;
(2) Long average life; and
(3) Economical Replacement costs.

The luminaire type recommended is the semi cut-off type.

4.5.6 Geology and Hydrology

a. Geology

4.084 The Irbid area lies on the northern part of the country and belongs to the semi-arid zone. The area is almost flat and generally slopes towards wadis in the west and east. The area is mostly covered with red and brown soil mixed with sandstone, limestone, chalk and basalt. The geology of the area is demonstrated in Figure 4.22.

b. Hydrology

i. Average Rainfall

4.085 In Figure 4.23, the thirty years mean annual rainfall indicates that the Irbid area receives 300 to 400 mm mean annual rainfall.

Average Annual Rainfall	300-400 mm
Average Mean Temperature in January	12°C
Average Mean Temperature in August	24°C

ii. Runoff and Calculations

4.086 At the level of the pre-feasibility study, runoff calculation is not necessary. But, for the convenience of the next step of the study which might come next year, the methodology of runoff calculation is introduced in this Section.

4.087 The quantity of runoff depends on many factors including the design, rainfall intensity, the time of concentration, the area of watershed, the nature of the area drained and the slope.

4.088 The time of concentration is the time required for a flow to become maximum at the location of the structure, and is a function of the length of water path and the fall measured from the head of the water to the site of the structure. It is calculated by the following formula:

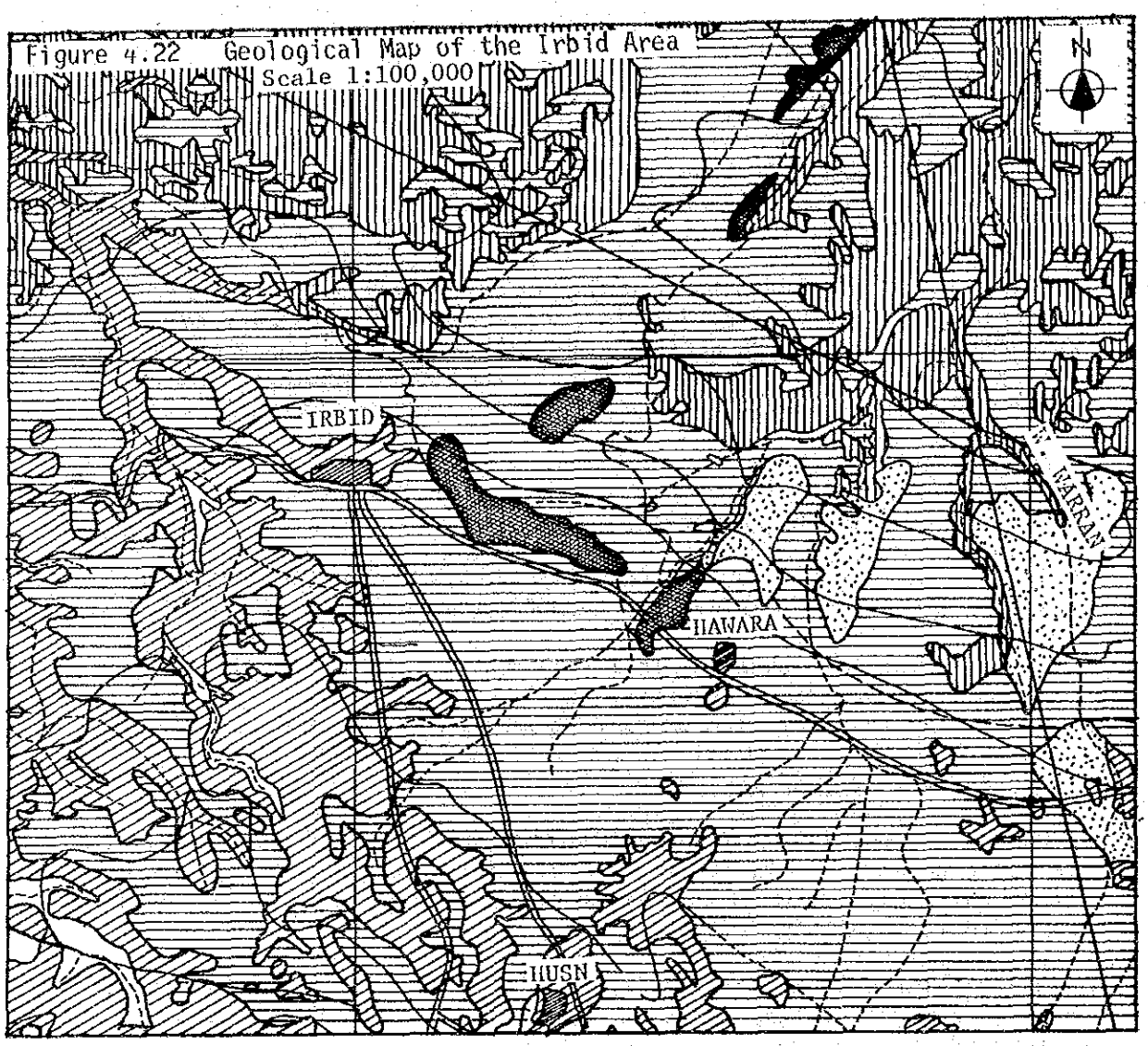
$$T = \left(\frac{0.87L^3}{H}\right)^{0.385}$$

where T = The time of concentration in hours;
L = Length of path in kilometers;
H = Difference of head in meters.

4.089 The determination of the design runoff will be made by using empirical relationships. A Rational Formula is used in the calculation of runoff and is represented in metric units as follows.

$$Q = \frac{1}{3.6} \times CIA$$

Figure 4.22 Geological Map of the Irbid Area
Scale 1:100,000



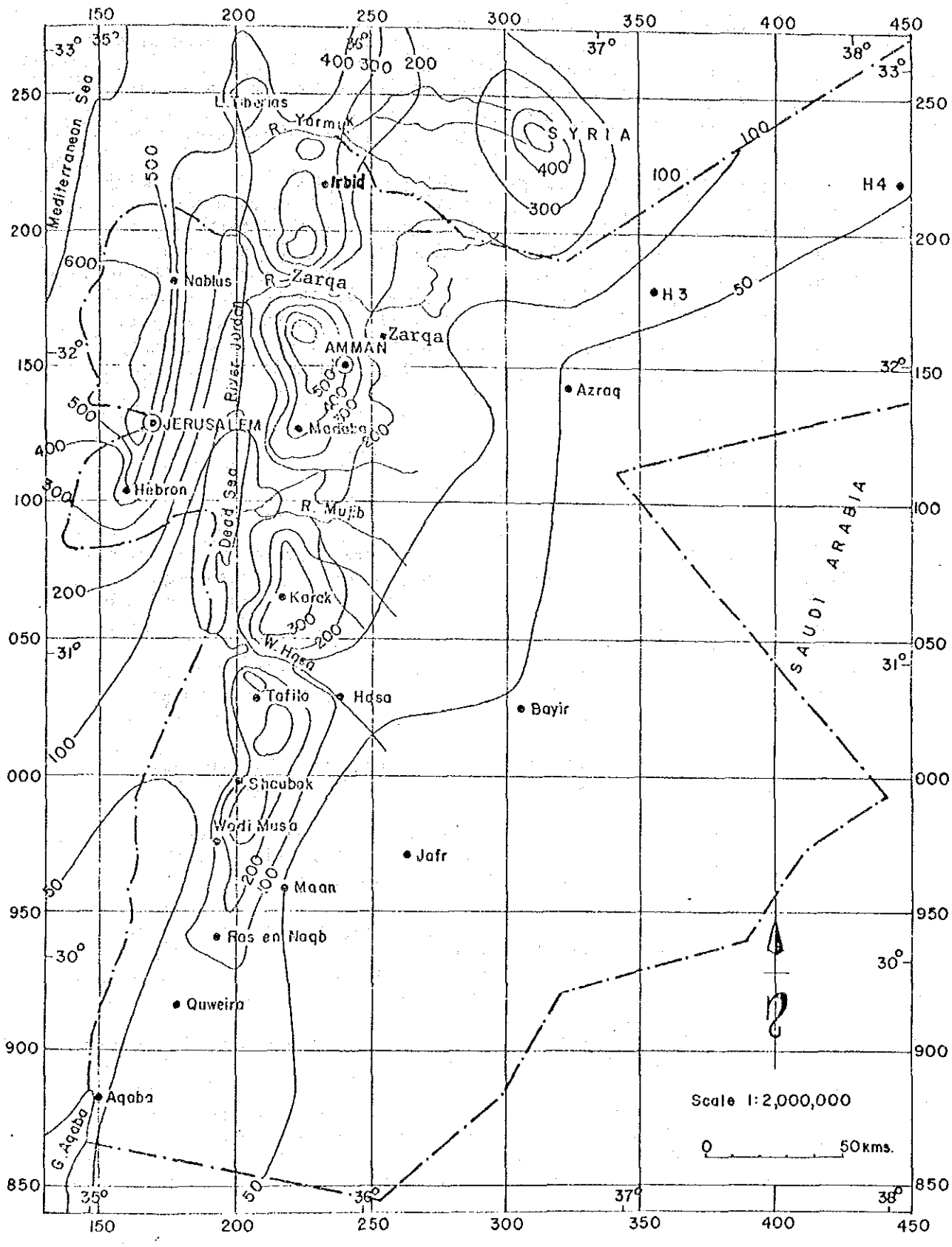
Legend

Source: Natural Resource Authority.

Age, Group	Formation	
Pleistocene-pecent	Plateau Gravel	Soils and Alluvia
		Basalt
		Undifferentiated
Paleocene-eocene		Lower Chalks
Upper Creataceous		Upper Limestones
Triassic Jurassic		Upper Limestones and Marls

Figure 4.23 Average Annual Rainfall in Jordan, 1938 to 1967

(Unit: mm)



Source: Ministry of Public Works, Zarq Highway Engineering Final Report.

where Q = Runoff in m^3/sec;
C = Runoff coefficient represents the ratio of peak runoff to peak rainfall;
I = Rain fall intensity in mm/hr for the design return period;
A = The area drained in square kilometers.

The Rational Formula is used for areas up to 40 km^2 and, when using the Rational Formula, it is assumed that the maximum volume of flow (i.e., water body) caused by a certain storm appears at the point of interest (i.e., the place where the Ring is) when the rainfall is maintained for a period equal to the time of concentration. The 10-year frequency intensity is used for box culvert and medium structures (see Figure 4.24), and the 50-year frequency intensity is used for bridges. The runoff coefficient varies from 0.25 to 0.8 depending on size, nature, slope and land use of the area drained.

4.6 Cost Estimates

4.6.1 General

4.090 The Study Team estimated unit prices of main construction items using basic elements such as labor, materials, equipment, overhead, profit, etc. The unit prices were computed in accordance with the following conditions.

(1) The estimates are made on the assumption that all construction works will be contracted to general contractors by international tender.

(2) The unit prices were computed under the economic conditions prevailing in September, 1978.

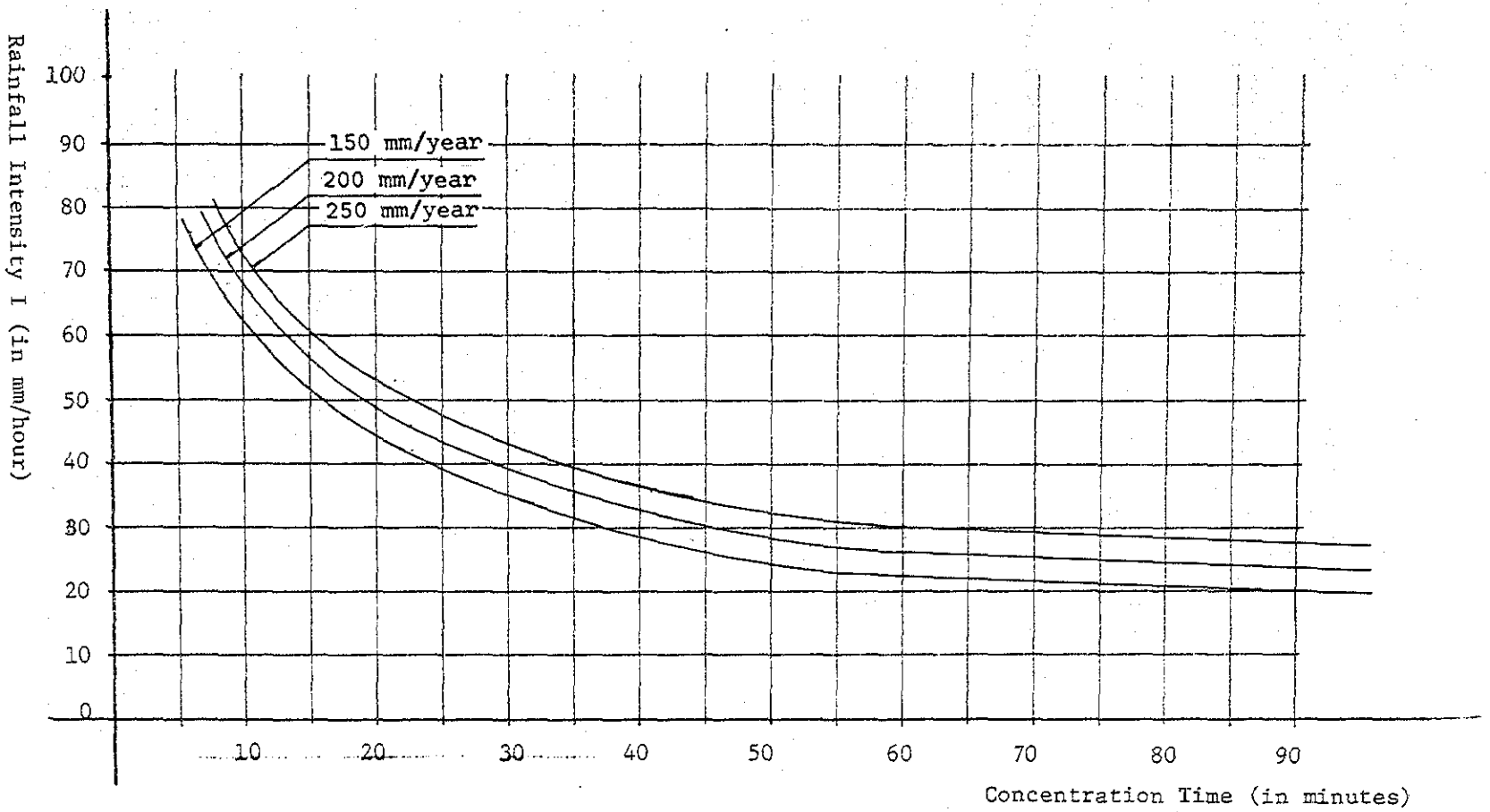
(3) The cost was classified into foreign currency (indicated in Jordan Dinars) and local currency (indicated in Jordan Dinars) portions.

(4) The unit prices of main work items are obtained by accumulating the labor cost, equipment cost, material cost, etc. The result is checked against recent actual figures for construction works in Jordan.

(5) Major materials costs are classified under the following items:

1) Fuel;
2) Reinforcing bars;
3) Fine Aggregate;
4) Coarse aggregate;
5) Cement; and
6) Asphalt.

Figure 4.24 Tentative Intensity Duration Curve (10 Year Frequency)



Source: N.W.M.P.

(6) The Jordan tax and duty on equipment and materials imported are included in the local currency portion.

(7) Land acquisition and compensation are based on the unit cost data obtained from the Irbid Municipality.

(8) For all unit prices, a constant allowance of 25 percent for overhead and profit was added to the direct unit prices.

(9) Contingency was assumed to be 10 percent of the total of construction cost, and land acquisition and compensation cost.

(10) The engineering, supervision fees and administration cost etc. were assumed to be 10 percent of the total construction cost.

(11) The rates of exchange used to convert the Jordan Dinar into Japanese Yen and US Dollars are JD 0.30 = US$1.0 = ¥220.

4.091 Foreign currency and local currency components of each unit price were computed based on the following classification of basic cost elements.

(1) The foreign currency component consists of the costs of:

1) Imported equipment, materials and supplies;
2) Domestic materials of which the country is a net importer;
3) Wages of foreign expatriate personnel; and
4) Overhead and profit of foreign firms.

(2) The local currency component includes the cost of:

1) Domestic materials and supplies of which the country is a net exporter;
2) Wages of local personnel;
3) Overhead and profits of local firms; and
4) Duties and taxes.

4.092 Although it is stated that duties on equipment and materials imported are included in the local currency portion, Jorean has a policy not to charge duties on production equipment and materials. For example, there is no import duty listed for construction equipment in customs tables. The only exception is iron. Duty on iron ingot is assessed at 2.5 percent. However, the total amount of duty on iron ingot is calculated to be about 0.02 percent of the total local currency portion, which is negligible. Thus, duties on imports are neglected in this cost calculation.

4.6.2 Unit Costs

a. Unit Costs of Materials

4.093 The unit cost data of materials were collected. The imported materials are costed at CIF Aqaba prices whereas those of local materials are based on the market prices in northern part of Jordan. The unit costs of the major material items are shown in Table 4.12.

Table 4.12 Unit Cost of Major Materials in Jordan, 1978

Major Material	Unit[1/]	Unit Cost F.C. Component (JD)	Unit Cost L.C. Component (JD)
Fuel (Diesel Oil)	lit	0.0168	0.0072
Reinforcing Steel Bar	ton	160	-
Fine Aggregate	cu.m	0.83	0.83
Coarse Aggregate	cu.m	0.85	0.85
Cement	ton	-	25
Asphalt	ton	9.6	14.4

Source: Ministry of Public Works.

Note: 1/ lit: liter cu.m: cubic meter

b. Unit Costs of Labor

4.094 The unit labor cost is based on the actual cost prevailing in the northern part of Jordan. The estimated labor rates include wages, social benefits, insurances, travel costs, sick leave, etc. The following are the costs by major labor classifications.

(1) Senior Supervisor (Foreign Labor) JD 65/day

(2) Supervisor JD 28.5/day
General Foreman, Foreman, Heavy Equipment Operator, Laboratory Supervisor

(3) Highly Skilled — JD 24.0/day
Mechanic, Lubrication Specialist, Grade Man

(4) Skilled — JD 20.0/day
Carpenter, Steel Worker, Mason, Truck Driver

(5) Common Labor — JD 9.5/day

c. Equipment Costs

4.095 An assessment of equipment-hourly-costs was made for the plant that would probably used in the construction of the project. These equipment rates are shown in Table 4.13. That is, the estimated hourly costs are calculated based on the estimated CIF unit prices at Aqaba, and the operation costs (fuel, lubricant and other expenses) are based on the market prices in the northern part of Jordan.

d. Unit Cost by Work Item

4.096 The unit cost by work item is calculated from the material cost, labor cost, equipment cost, etc., taking into consideration the local conditions; the results of the major unit costs by work items are listed in Table 4.14.

4.6.3 Land Acquisition and Compensation Costs

4.097 The land acquisition and housing compensation costs were calculated according to the data on land prices and compensation prices obtained from the Irbid Municipality. It was noted for calculation purposes that the executing agency could acquire 25 percent of a parcel of land which was crossed by the Ring Road without giving any compensation.

4.098 Land prices around the Ring Roads are shown in Figure 4.25 which appears later. Average compensation cost for a house was estimated to be JD 4,500. The total compensation cost was estimated to be JD 325,000.

4.6.4 Construction Cost Estimated in 1978 Prices

4.099 The preliminary construction cost estimates are made based on the quantities estimated in the preliminary design and on the unit costs by work items. The cost is split into foreign currency and local currency components. The calculation method is summarized in Table 4.15 and the summary of the calculation is listed in Tables 4.16, 17 and 18.

Table 4.13 Equipment Direct Cost per Hour in Jordan, 1978

(Unit: JD/hour)

No.	Equipment	Direct Hourly Costs Foreign (JD)	Local (JD)
1.	Bulldozer 17 ton Class	6.501	2.151
2.	Bulldozer 21 ton Class	9.422	3.343
3.	Motor Scraper (8 m^3)	7.548	2.727
4.	Convertible Excavator (0.6 m^3)	5.580	1.913
5.	Wheel Loader (1.4 m^3)	5.953	1.736
6.	Dump Truck (3.0 m^3)	1.072	0.473
7.	Flatbed Truck (4.5 ton)	1.220	0.521
8.	Fuel Tanker (5,000 litters)	1.524	0.561
9.	Cross-country Jeep	1.123	0.462
10.	Truck Crane (10 ton)	4.446	1.768
11.	Rock Drill	0.723	0.092
12.	Motor Grader	4.825	1.765
13.	Tandem Road Roller (8 ton)	2.716	1.101
14.	Macadam Road Roller (8 ton)	2.263	0.942
15.	Aggregate Spreader	14.455	4.757
16.	Stone Crushing Plant	26.728	4.607
17.	Concrete Mixer Truck (1.7 m^3)	1.809	0.662
18.	Vibrator	0.914	0.192
19.	Concrete Batching Plant (40 m^3/hr)	6.839	2.122
20.	Asphalt Plant (100 ton/hr)	54.113	65.605
21.	Asphalt Distributor (4,000 liters)	5.100	1.860
22.	Bituminous Spreader (5 m)	9.662	3.191
23.	Asphalt Kettle (5,000 liters)	2.784	0.634
24.	Mechanical Broom	1.196	0.493
25.	Portable Air Compressor	14.613	4.082
26.	Generator 30 kVA	4.249	1.317
27.	Generator 50 kVA	6.523	2.047

Source: Ministry of Public Works & Study Team.

Table 4.14 Major Unit Cost of Work Item in Jordan, 1978

Item No.	Description	Unit[1/]	Unit Cost[2/] F.C. in JD	Unit Cost[2/] L.C. in JD
0100	General	l.s.		
0201	Clearing & Grubbing	sq.m.		
0202	Common Excavation	cu.m.	0.920	0.493
0203	Borrow Excavation	cu.m.	0.867	0.761
0301	Pipe Culverts with handwalls (0.6)	l.m.	6.662	15.890
0302	Other Drainage Facilities	l.s.		
0401	Asphalt Concrete Surface (t = 10 cm)	sq.m.	0.890	0.654
0402	Base Course	cu.m.	2.275	2.062
0403	Subbase Course	cu.m.		
0501	Short Span Bridge R.C. Slab. L = 12 m)	sq.m.	78.333	65.426
0502	Box Culverts with Headwalls			
0601	Stone Masonry	sq.m.	4.580	13.710
0602	Concrete Curb	l.m.	0.987	1.362
0603	Lighting with Post	each	607.500	61.150
0604	Traffic Signals at Crossing Roads	palce	3,902.200	34.910
0605	Other Incidental Works			
0700	Land Acquisition			
0800	Compensation			

Source: Ministry of Public Works & Study Team.

Notes: 1/ l.s.: lump sum sq.m.: square meter
l.m.: linear meter cu.m.: cubic meter

2/ F.C.: Foreign Currency
L.C.: Local Currency

Table 4.15 Calculation Method of Total Project Cost

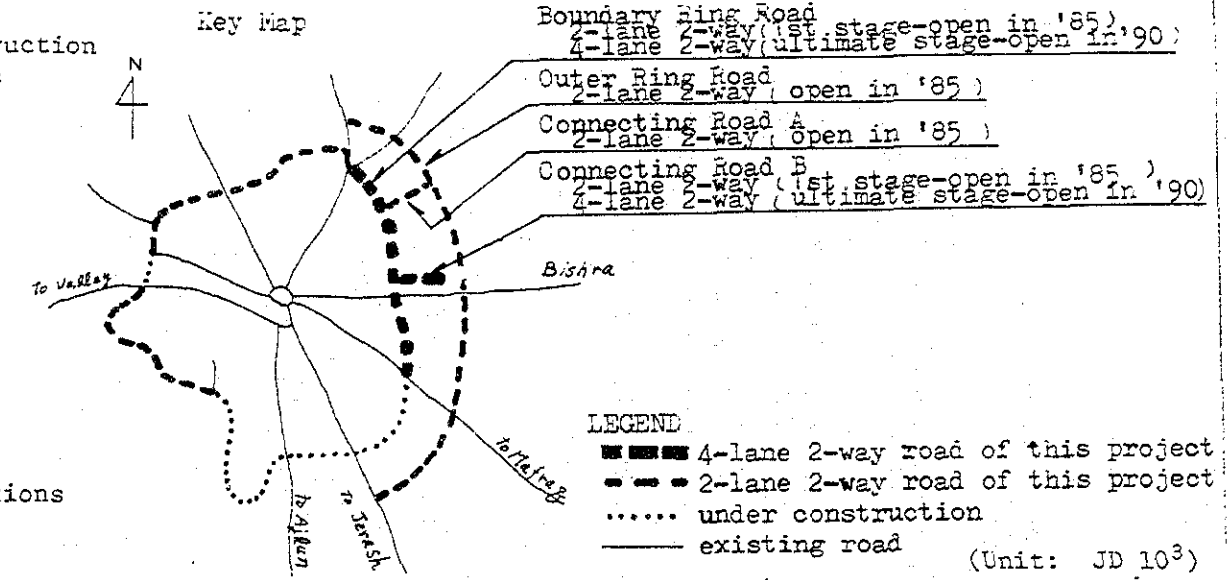
Item No.	Description	Remarks[1/]
0100	General	
0200	Earthwork	(item 0201 - 0203)
0300	Drainage Structures	(item 0301 - 0302)
0400	Pavement	(item 0401 - 0403)
0500	Structures	(item 0501 - 0502)
0600	Miscellaneous	(item 0601 - 0605)
0001	Total Construction Cost	(item 0100 - 0600)
0700	Land Acquisition	
0800	Compensation	
0002	Total Land Acquisition and Compensation Cost	(item 0700 + 0800)
0003	Contingencies	(item 0001 + 0002) x 0.10
0004	Final Engineering, Supervision Administration and Others	(item 0001) x 0.10
0000	Total Project Cost	(item 0001 - 0004)

Source: Study Team.

Note: 1/ *Detail of each item number is shown in Table 4.14.*

4.100 As the Tables show, the total project cost of the Ring Roads is estimated at JD 2.9108 million for the First Stage (1982 to 1984) plus JD 0.318 million for the Ultimate Stage (1989) at 1978 prices. In total, the project cost amounts to JD 3.2289 million at 1978 prices.

Table 4.16 Summary of Estimated Construction Cost for RRI at 1978 Prices (1st Stage)



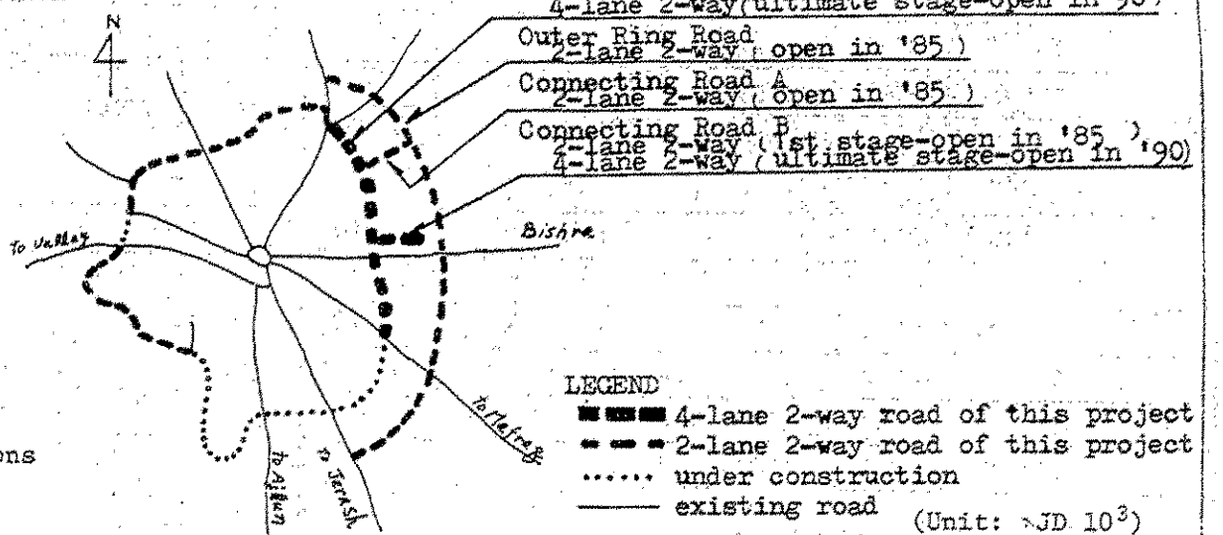
Source: Estimated based on the informations from Ministry of Public Works.

(Unit: JD 10^3)

ITEM NO.	Description	Boundary Ring Road		Outer Ring Road		Connecting Road A & B		Summary			Remarks
		F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	G.Total	
0100	General	72.6	41.8	35.3	21.3	8.6	4.2	116.5	67.3	183.8	
0200	Earthwork	163.3	90.5	16.7	14.6	9.2	4.9	189.2	110.0	299.2	
0300	Drainage Structures	12.8	40.9	9.7	32.3	2.0	6.5	24.5	79.7	104.2	
0400	Pavement	170.1	135.2	112.3	89.2	17.8	14.7	300.2	239.1	539.3	
0500	Structures	6.7	8.0	-	-	-	-	6.7	8.0	14.7	
0600	Miscellaneous	258.3	81.2	155.5	41.0	42.7	8.8	456.5	131.0	587.5	
0001	Total Construction Cost	683.8	397.6	329.5	198.4	80.3	39.1	1093.6	635.1	1728.7	
0700	Land Acquisition	-	237.2	-	163.3	-	18.9	-	419.4	419.4	
0800	Compensation	-	325.0	-	-	-	-	-	325.0	325.0	
0002	Total Land Acquisition and Compensation Cost	-	562.2	-	163.3	-	18.9	-	744.4	744.4	
0003	Contingencies	68.4	96.0	41.7	36.2	8.0	5.8	118.1	138.0	256.1	
0004	Engineering, Supervision	68.4	39.8	41.7	19.8	8.1	3.9	118.2	63.5	181.7	
0000	Total Project Amount	820.6	1,095.6	412.9	417.7	96.4	67.7	1329.9	1581.0	2910.9	

Table 4.17 Summary of Estimated Construction Cost for RRI at 1978 Prices (Ultimate Stage)

Key Map



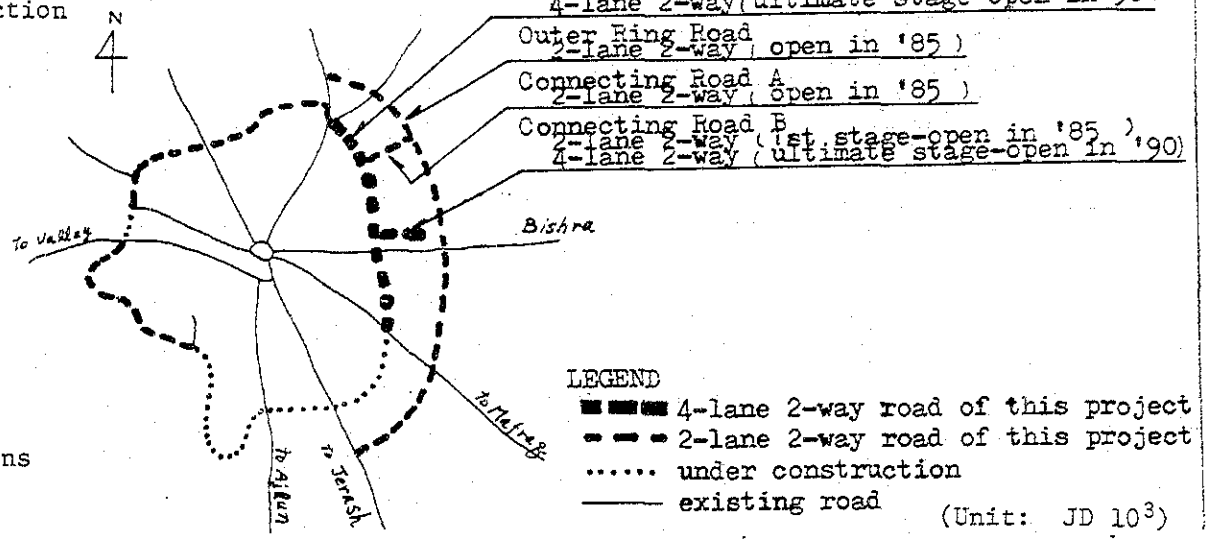
Source: Estimated based on the informations from Ministry of Public Works.

(Unit: JD 10^3)

ITEM NO.	Description	Boundary Ring Road		Connecting Road B				Summary			Remarks
		F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	G.Total	
0100	General	14.5	7.0	3.6	1.8			18.1	8.8	26.9	
0200	Earthwork	9.2	4.9	4.6	2.5			13.8	7.4	21.2	
0300	Drainage Structures	3.0	10.3	0.7	2.4			3.7	12.7	16.4	
0400	Pavement	40.8	34.4	8.0	6.6			48.8	41.0	89.8	
0500	Structures	-	-	-	-			-	-	-	
0600	Miscellaneous	71.2	19.2	16.8	3.5			88.0	22.7	110.7	
0001	Total Construction Cost	138.7	75.8	33.7	16.8			172.4	92.6	265.0	
0700	Land Acquisition	-	-	-	-			-	-	-	
0800	Compensation	-	-	-	-			-	-	-	
0002	Total Land Acquisition and Compensation Cost	-	-	-	-			-	-	-	
0003	Contingencies	13.8	7.6	3.4	1.7			17.2	9.3	26.5	
0004	Engineering, Supervision	13.8	7.6	3.4	1.7			17.2	9.3	26.5	
0000	Total Project Amount	166.3	91.0	40.5	20.2			206.8	111.2	318.0	

Table 4.18 Summary of Estimated Construction Cost for RRI at 1978 Prices (Breakdown of 1st Stage Boundary Ring Road)

Key Map



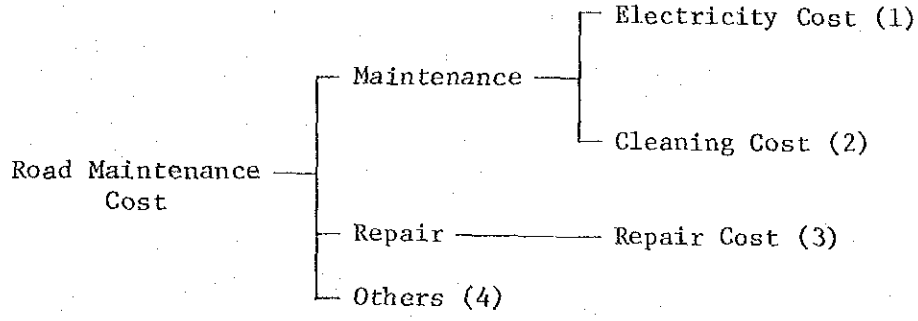
Source: Estimated based on the informations from Ministry of Public Works.

(Unit: JD 10^3)

ITEM NO.	Description	KM 0.0 - KM 4.0		KM 4.0 - KM 8.9		KM 9.27-KM12.67		Summary			Remarks
		F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	G.Total	
0100	General	16.2	8.5	27.3	15.0	29.1	18.3	72.6	41.8	114.4	
0200	Earthwork	8.7	7.6	44.2	23.7	110.4	59.2	163.3	90.5	253.8	
0300	Drainage Structures	3.6	11.0	5.3	17.4	3.9	12.5	12.8	40.9	53.7	
0400	Pavement	47.6	37.9	72.3	57.4	50.2	39.9	170.1	135.2	305.3	
0500	Structures	-	-	-	-	6.7	8.0	6.7	8.0	14.7	
0600	Miscellaneous	75.0	14.0	105.4	26.4	77.9	40.8	258.3	81.2	339.5	
0001	Total Construction Cost	151.1	79.0	254.5	139.9	278.2	178.7	683.8	397.6	1081.4	
0700	Land Acquisition	-	145.4	-	54.2	-	37.6	-	237.2	237.2	
0800	Compensation	-	-	-	200.0	-	125.0	-	325.0	325.0	
0002	Total Land Acquisition and Compensation Cost	-	145.4	-	254.2	-	162.6	-	562.2	562.2	
0003	Contingencies	15.1	22.4	25.5	39.4	27.8	34.2	68.4	96.0	164.4	
0004	Engineering, Supervision	15.1	7.9	25.5	14.0	27.8	17.9	68.4	39.8	108.2	
0000	Total Project Amount	181.3	524.7	305.5	447.5	333.8	393.4	820.6	1095.6	1916.2	

4.6.5 Maintenance Cost

4.101 Maintenance has been defined as "(1) the preserving and keeping of each type of roadway, roadside, structure and facility as nearly as possible in its original conditions as constructed or as subsequently improved, and (2) the operation of road facilities and services to provide satisfactory and safe transportation". The road maintenance cost is estimated for the following items.



(1) Electricity Cost:

This includes the cost of electricity for lighting and other facilities and services.

(2) Cleaning Cost:

This includes the cost of cleaning the road surface, drainage, facilities, regulartory signs, lighting and other services.

(3) Repair Cost:

This includes the cost of road surface repairs, overlays, painting of traffic markings, etc., inspection of structures, expansion joint repairs and inspection and repair of electric and traffic faciliteis.

(4) Indirect Cost:

This is assumed at 10 percent of the total of items (1) to (3).

4.102 The road maintenance costs per each item are estimated being shown in Table 4.19.

Table 4.19 Road Maintenance Cost per Kilometer per Year

(Unit: JD/km/Year)

Items	Unit (km)	Unit Cost per km per Year
1) Electricity Cost	Road Length	JD 1,533
2) Cleaning Cost	Road Length	1,073
3) Repair Cost	Road Length	2,064
4) Indirect Cost	Road Length	467
Total		JD 5,137

Source: Study Team.

Note: The road width consists of 2 lanes carriage ways, 1 or 2 lane parking strips and side walks.

The result of the calculations for each road is summarized in Table 4.20.

Table 4.20 Maintenance Cost per Year

Destination	Road Length	Maintenance Cost
Boundary Ring Road (1st Stage), 2 Lanes	12.30 km	JD 63,185
Boundary Ring Road, Add. 2 lanes 1/	4.0	20,548
Outer Ring Road	7.7	39,555
Connecting Road (A + B), 2 lanes	2.0	10,274
Connecting Road B, Add. 2 lanes 1/	1.0	5,137
Total (Ultimate Stage)		JD 138.7 x 10^3

Source: Study Team.

Note: 1/ Indicates Ultimate Stage.

4.7 Economic Study

4.7.1 General

4.103 An economic study was undertaken for the two Alternatives explained in Sections 4.4.4 and 4.5.3. This Study consists of the following three steps. The first is to give preliminary estimates of the economic costs and benefits which accrue to each Alternative. The second is to judge which Alternative would be more advantageous from the economic viewpoint by employing benefit-cost analysis. The third is to reexamine the economic feasibility of the selected Alternative by adopting another benefit estimation method. As a consequence, the benefits were estimated by two different methods. The economic life of the project was assumed to be 20 years.

4.7.2 Economic Cost

4.104 In Section 4.6, the project cost is estimated in 1978 prices for the foreign and local currency portions. Thus, in this section these costs such as construction costs, land acquisition costs, compensation costs and maintenance costs must be converted to economic costs for the purposes of benefit-cost analysis.

(1) The Economic Construction Costs:

Financial costs estimated in Section 4.6 have been analyzed. The economic construction costs were estimated based on 1978 prices with the deduction of duty and duty components. According to the Highway Study Report on Route 11 and Autostrada by the Ministry of Public Work, the conversion rates of labor cost, diesel oil, cement and asphalt were estimated at 0.95, 0.70, 0.65 and 0.70 respectively.

(2) The Economic Land Acquisition Costs:

The economic land costs were measured by market price which was identified in Figure 4.25. The prices of JD 3.5 to 13.5 per square meter were used for accounting the whole land area to be used for the Ring Roads. The economic compensation costs of buildings were given the same value as shown in Section 4.6.

(3) The Economic Maintenance Costs

The economic maintenance costs were measured by the same value as shown in Section 4.6 because the maintenance costs are so small that effects of the conversion factors were negligible.

4.105 The 1978 present values of the economic construction, land acquisition, compensation and maintenance costs were computed at annual discount rates of 9 percent, 12 percent and 15 percent. This was done for both Alternative I and Alternative II. The results are shown in Table 4.21. For example, 1978 present value of the economic total cost discounted at 12 percent per annum was estimated to be JD 4.0464 million for Alternative I, and that for Alternative II to be JD 2.8183 million.

4.106 In order to show the calculation process, as a sample, the discounting table of the economic for Alternative I is shown in Table 4.22. Its construction schedule is based on that shown in Section 4.8.

Table 4.21 1978 Present Values of Total Economic Costs of RRI

(Unit: JD 1,000 in 1978 prices)

Alternative	1978 Present Values of Economic Total Cost Discounted at		
	9%	12%	15%
Alterantive I	4,742.3	4,046.4	3,462.8
Alternative II	-	2,818.3	2,443.9

Source: Study Team.

4.7.3 Benefit Estimation Method

4.107 In general, the most important economic benefits derived from construction of a road should include:

(1) Promotion of economic productivity;

(2) Reduced operating expenses initially to the users of the new road or sometimes also to those who continue to use the existing roads;

(3) Savings in time for both passengers and freight;

(4) Fewer accidents and reduced damage; and

(5) Increased comfort and convenience.

Table 4.22 Discounting Table of Economic Total Cost for the Project Life Span of 20 Years, 1978 to 2004

Alternative I, at Annual Discount Rate 12%

(Unit: JD in 1978 prices)

	Year	Discount Factor	Investment Schedule by Year			Present Value Discount at 12%
			Const.	Land & Compensation	Maintenance	
	1978					0
	79					0
	80					0
	81					0
	82	0.635518		3,722,100		2,368,639
	83	0.567427	938,745			532,669
	84	0.506631	1,147,355			581,286
1	85	0.452349			113,000	51,115
2	86	0.403883			113,000	45,639
3	87	0.360610			113,000	40,749
4	88	0.321973			113,000	36,383
5	89	0.287476	299,000		113,000	118,440
6	90	0.256675			138,700	35,601
7	91	0.229174			138,700	31,786
8	92	0.204620			138,700	28,381
9	93	0.182696			138,700	25,340
10	94	0.163122			138,700	22,625
11	95	0.145644			138,700	20,201
12	96	0.130064			138,700	18,040
13	97	0.116107			138,700	15,827
14	98	0.103667			138,700	14,379
15	99	0.092560			138,700	12,838
16	2000	0.082643			138,700	11,643
17	01	0.073788			138,700	10,234
18	02	0.065882			138,700	9,138
19	03	0.058823			138,700	8,159
20	04	0.052521			138,700	7,285
1978 Present Value of Economic Total Cost						4,046,397

Source: Study Team.

4.108 All the benefits above are closely related to each other, and there may sometimes be a duplication in benefit counting. As mentioned previously, two estimation methods were used in this Study. One is the method of calculating the incremental land value as a benefit. The other method is to calculate the improvement in traffic conditions by the development of a new road; i.e., mainly the benefits of (2) and (3) above described.

4.109 As to the first method, land values along the project site would certainly increase following the construction of Ring Roads. The land value is thought to be representing the economic productivity, i.e., the total present worth of the value added which are expected to be derived from an economic activity on the corresponding land. This incremental land value is considered to be stemming from a reduction of costs relating to production and/or distribution, i.e., stemming from benefits (2) and (3) stated above, and other intangible benefits. Accordingly, the incremental land value is regarded as the major benefit from the new road.

4.110 As to the second method, this is the coventional mehtod in estimating economic benefits. This method is likely to under-estimate the benefits, since only those (2) and (3) are usually calculated due to the difficulty in assessing others. However, this method is rather orthodox and more broadly prevailing for the estimation of benefits than the first one.

4.111 Therefore, the first method was used for the selection of the best alternative among the two, and the second one was applied for ensuring the economic feasibility of the project.

4.7.4 Benefit Estimation

a. Estimation by Method 1

4.112 First of all, the market prices of land were surveyed by using information available from the Land and Survey Department in Irbid because they were considered to be representative of land values. For the survey, 25 points were selected from all areas of Irbid City.

4.113 Land price generally has a tendency to decrease in accordance with the distance from the city center. The distance from the center seems to be represented by the accessibility rather than the actual distance. For an indicator of accessibility, therefore, the approximate time required to get to the center from each point was measured. The roads between the center and each point were classified into four grades, A to D, in terms of the service quality; the indicators were calculated based on these grades. The speeds by grade were assumed as follows:

	Right of Way	Speed
Grade A	over 30 m	60 km/hr
" B	" 20 m	40 km/hr
" C	" 10 m	15 km/hr
" D	-	4 km/hr

4.114 The land prices and the indicators at the corresponding locations were plotted in Figure 4.25. The land price seems to vary in relation to population density and, therefore, the following equation, which was used for the population density curve in Chapter II, was employed in order to represent the land price curve.

$$P = ae^{-bx}$$

where P: Land price;
x: Accessibility indicator;
a, b: Constant parameters; and
e: Base of natural logarithm.

The parameters a and b were calibrated as follows by regression analysis with a relatively high correlation coefficient.

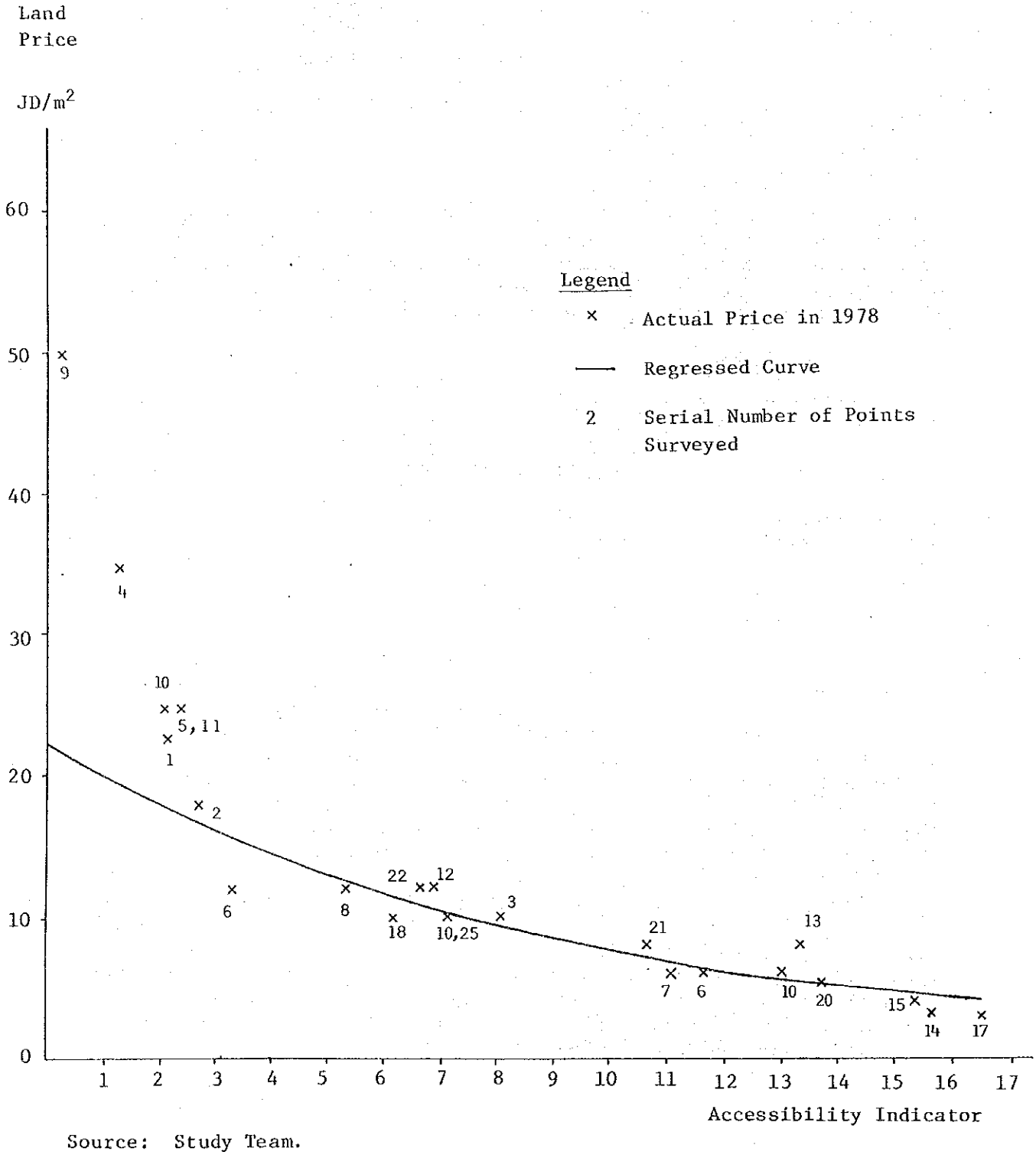
$a = 21.8$
$b = 0.1026$
$r = 0.91$ (correlation coefficient)

The estimated curve, together with actual prices, is shown in Figure 4.25.

4.115 The curve shows lower estimates than the acutal ones at the area around the center of the city. This discrepancy is considered to be the additional land value due to commercial activities, therefore, the closer the center, the larger the discrepancy becomes. However, the curve almost fits the actual ones at the area which is further than 2.5 or 3.0 in terms of the indicator. This implies that the influences on the land value imported by the commercial activities can be neglected at the area reasonably distant from the center.

4.116 The annual escalation of land price is considered to be composed of two components, one is the inflation of commodities and the other is due to population growth. The population and the built-up area in Irbid as of 1978 as well as 1985 and 2000 are given in Table 4.23, which was estimated in Chapter II.

Figure 4.25 Land Price Distribution in Irbid City, 1978



Source: Study Team.

Table 4.23 Population in Irbid, 1978, 1985 and 2000

Year	Population	Built-up Area	Radius of Built-up Area
1978	142,000 persons	11.37 km^2	1.901 km
1985	182,600	20.12	2.531
2000	304,000	40.29	3.581

Source: Study Team.

4.117 In terms of the accessibility indicator, the fringe of the built-up area in 1978 was at the distance of 16.5 from the center. Assuming that this distance corresponds to the radius of built-up area in Table 4.23, the fringe in 1985 will be at the distance of 22.0 in terms of the indicator. Provided that the land price at the fringe of the built-up area remains unchanged, the following land curve is obtained for 1985.

$$P = 32.8\ e^{-0.1026\ x}$$

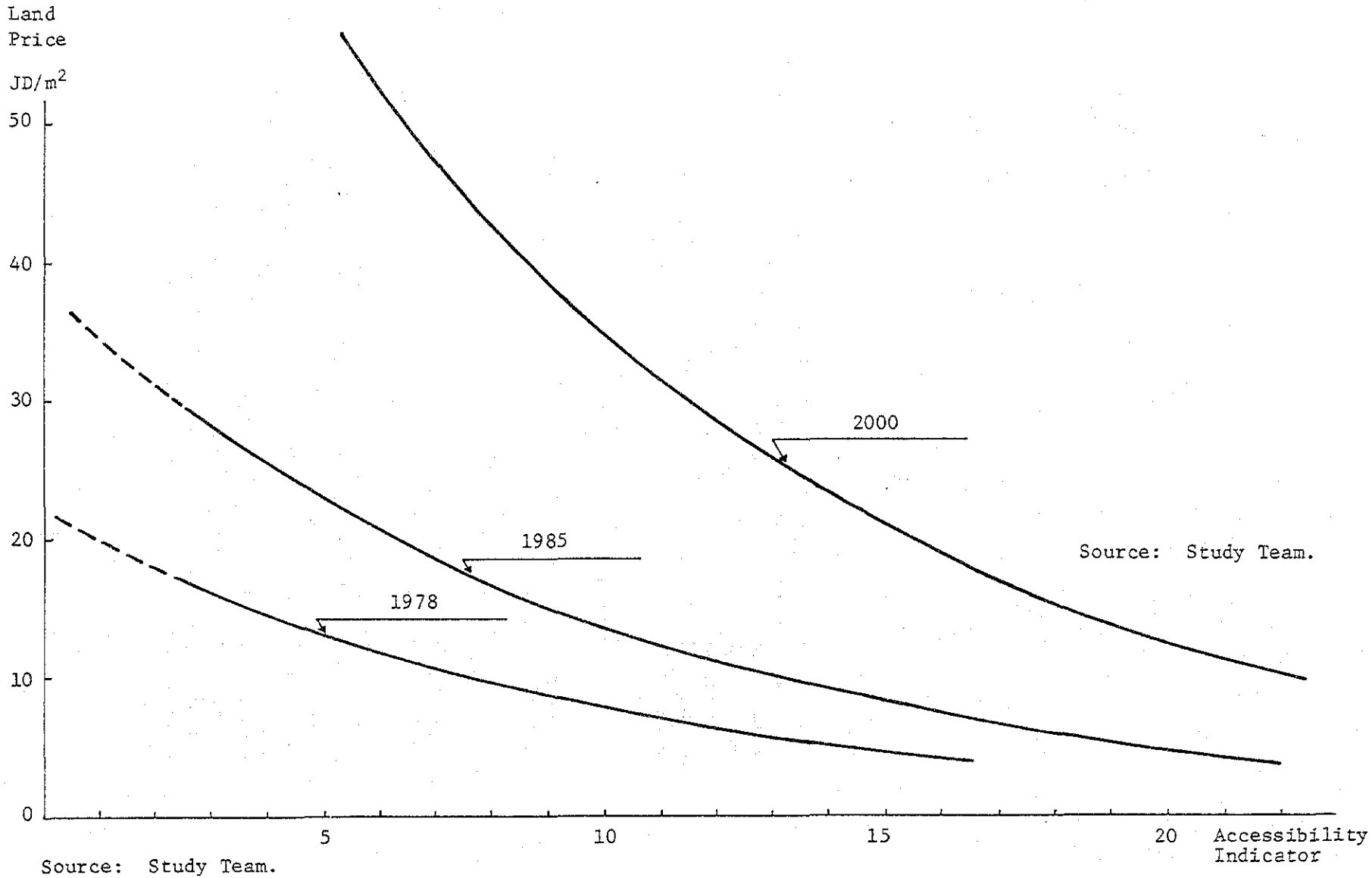
In the same fashion, the land price curve in 2000 can be calculated as follows.

$$P = 97.2\ e^{-0.1026\ x}$$

The estimated curves are depicted in Figure 4.26. They are represented at 1978 constant price.

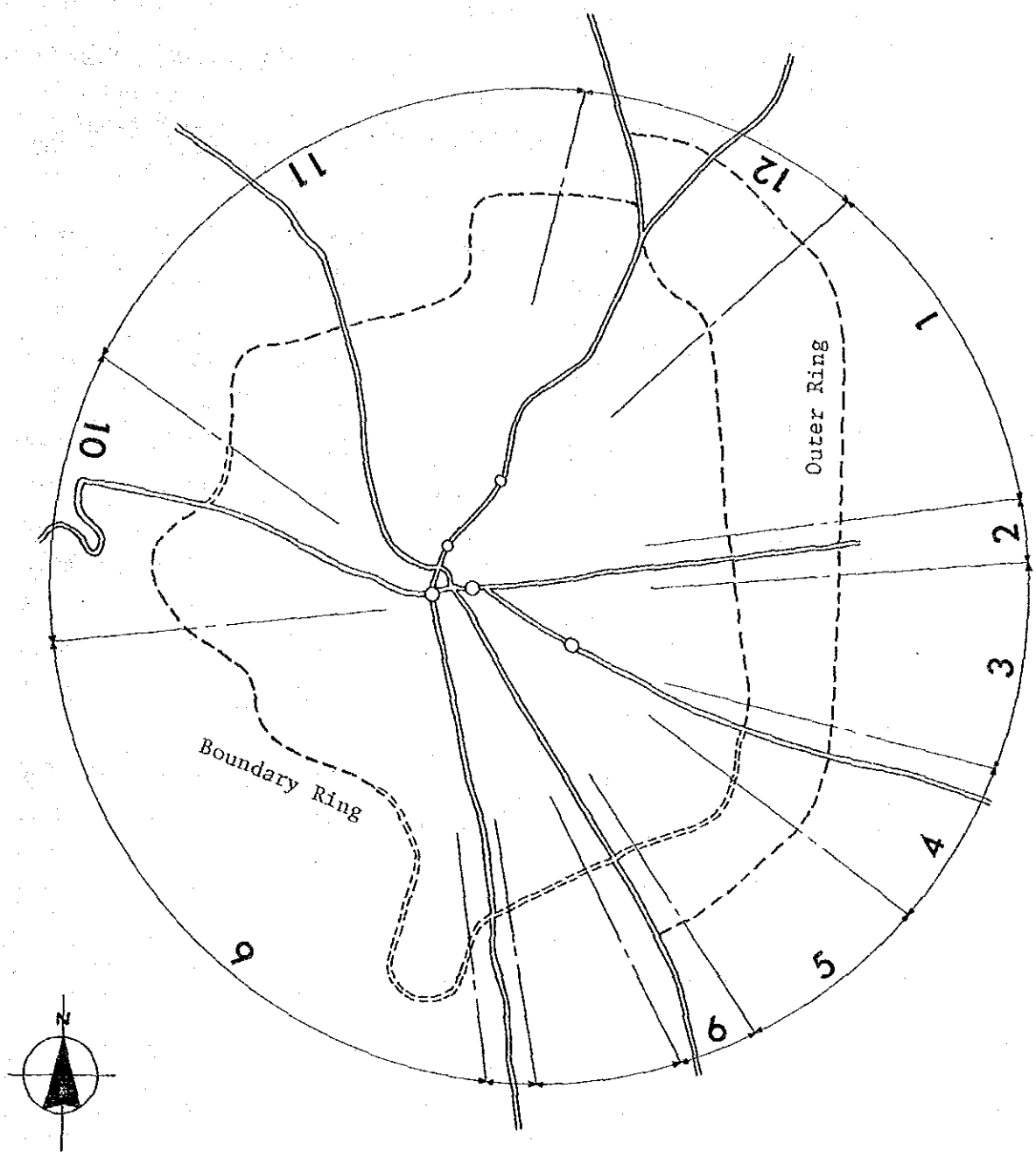
4.118 The construction of a road will contribute to improvement of the accessibility to the city center. Hence, using the land price curves, the incremental land value created by the project can be estimated by calculating the difference of the land prices due to the improved accessibility. For this purpose, the Ring Roads were divided into 12 sections as shown in Figure 4.27, and the land prices with and without the project were compared. The comparison of the land prices are given in Table 4.24. The land price in the Table represents the average price of the corresponding section.

Figure 4.26 Estimated Land Price Curve in the City of Irbid, 1978, 1985 and 2000 (1978 Price)



Source: Study Team.

Figure 4.27 Sections of Ring Roads of Irbid



0 1 2 km

Scale 1:50,000

Source: Study Team.

Legend

Existing Road

Under Construction

Planned

5 Ring Road Section

Table 4.24 Comparison of Land Prices in the City of Irbid, 1978, 1985 and 2000

(Unit: JD/m^2 in 1978 prices)

Section No.	Land Prices Without Project			Land Prices with Project	
	1978	1985	2000	1985	2000
Boundary Ring					
1	6.0	10.5	26.7	23.5	59.7
2	13.0	22.8	57.9	28.5	72.4
3	7.6	13.3	33.8	28.5	72.4
4	13.5	23.6	59.9	29.5	74.9
5	7.5	13.1	33.3	27.8	70.6
6	12.5	21.9	55.6	29.5	74.9
7	9.0	15.8	40.1	27.8	70.6
8	13.0	22.8	57.9	29.5	74.9
9	6.5	11.4	29.0	24.0	61.0
10	12.5	21.9	55.6	28.5	72.4
11	5.0	8.8	22.4	23.0	58.4
12	10.0	17.5	44.5	25.8	65.5
Outer Ring					
1	3.8	6.7	17.0	14.0	35.6
2	7.4	13.0	33.0	15.8	40.1
3	5.5	9.6	24.4	23.5	59.7
4	11.8	20.7	52.6	26.5	67.3
5	5.5	9.6	24.4	25.3	64.3
6	11.8	20.7	52.6	26.5	67.3
12	7.5	13.1	33.3	18.3	46.5

Source: Study Team.

4.119 The greater portion of the area around the project site is utilized for agriculture at present. But the land use around the Ring Roads will be changed by the project, partly to industrial or commercial use and most likely to residential use. The benefits brought about by the Ring Roads should be calculated only for the area of residential use. The reason is that the area for industrial/commercial use might occupy a minor portion of the built-up area.

4.120 In accordance with the estimation of the land demanded for residential use, we have calculated the population density along the two Ring Roads, the Boundary Ring and the Outer, as shown in Table 4.25. The demanded area for land can be obtained by assuming that the family size be 7.5 persons on average and the unit size of a plot of land be 500 m^2 per family, taking into account that the minimum unit size regulated by law is 1,000 m^2 for the high grade residential area, and 200 m^2 for the low grade.

4.121 The benefits from the project can be calculated by the following formula.

(Benefit) = (Incremental Land Value) x (Demanded Area)
- (Grubbing & Clearing Costs)

Assuming that the costs for grubbing and clearing the land are JD 0.3/m^2, the benefits were calculated for the two Alternatives mentioned in Sections 4.4.4 and 4.5.2. The results are given in Table 4.26 in the form of the benefit stream.

4.122 The total present worth as of 1978 will be JD 4,766,000, JD 3,313,000 at the discount rate of 12 percent for the respective alternatives.

b. Estimation by Method 2

i. General

4.123 As will be found in the subsequent economic evaluation, Alternative I is more beneficial than Alternative II. Therefore, the estimation of benefits by this method was made only for Alternative I, in order to make sure the feasibility of Alternative I.

4.124 Among the various benefits that can be realized from the implementation of the project, savings in travel time and running expenses are considered most significant. These benefits are defined as the difference of the travel times and the running expenses hitherto affected with and without the project.

4.125 Whether or not the time saved by passengers should be counted as benefit is dependent on (1) whether they use the extra time for directly productive activity (work) or voluntary leisure or (2) whether it merely increases unemployment or not. In view of the fact that the unemployment rate in the East Bank is very low--less than 5 percent--we can assume that about 50 percent of the saved time will be utilized for productive activities, taking into account the underemployment.

Table 4.25 Estimated Population Density at Project Site, 1985 and 2000

(Unit: persons/ha)

Section No.	1985	2000
Boundary Ring		
1	30.0	48.9
2	101.4	183.7
3	57.8	63.1
4	269.6	273.7
5	10.0	23.8
6	13.9	33.4
7	13.9	45.6
8	127.9	130.0
9	12.6	62.9
10	42.2	55.2
11	10.0	25.3
12	65.0	87.4
Outer Ring		
1	10.0	15.3
2	39.3	102.7
3	21.2	21.4
4	188.1	207.8
5	0	10.0
6	0	14.4
12	34.8	53.6
Connecting Rd. A	20.0	32.1
Connecting Rd. B	70.4	143.2

Source: Study Team.

Table 4.26 Estimated Benefit Stream by Method 1, Alternatives I and II

(Unit: JD 1,000 in 1978 prices)

Year	Section No. of Boundary Ring								Section No. of Outer Ring							Connecting		Total	
	1	2	3	4	9	10	11	12	1	2	3	4	5	6	12	A	B	Alt. I	Alt. II
1985	812.8	324.6	997.9	204.0	134.9	243.2	567.3	1,040.4	196.0	65.5	467.9	910.0	0.0	0.0	386.5	203.5	323.0	6,877.5	4,528.6
1986	37.8	19.0	6.7	-	44.2	5.8	67.4	26.5	7.7	7.9	0.3	-	19.7	2.3	15.4	9.1	24.4	294.2	216.5
1987	41.3	20.6	7.4	-	52.3	6.6	77.4	29.0	8.4	8.7	0.3	-	21.6	2.6	16.9	9.9	26.5	329.3	244.5
1988	44.8	22.2	8.1	-	60.3	7.5	87.3	31.5	9.2	9.5	0.4	-	23.5	2.8	18.4	10.8	28.6	365.3	272.6
1989	48.3	23.8	8.7	-	68.4	8.3	97.3	34.1	9.9	10.3	0.4	-	25.3	3.0	20.0	11.7	30.7	400.3	300.6
1990	51.8	25.4	9.4	-	76.5	9.1	107.3	36.6	10.6	11.1	0.4	-	27.2	3.2	21.4	12.5	32.8	435.3	328.6
1991	55.4	27.0	10.1	-	84.5	9.9	117.3	39.2	11.4	12.0	0.4	-	29.1	3.4	22.9	13.4	34.9	471.3	356.7
1992	58.9	28.6	10.7	-	92.6	10.7	127.3	41.7	12.1	12.8	0.5	-	30.9	3.7	24.4	14.3	36.0	506.3	384.7
1993	62.4	30.2	11.4	-	100.7	11.5	137.2	44.3	12.9	13.6	0.5	-	32.8	3.9	26.0	15.1	38.1	535.9	412.8
1994	65.9	31.8	12.1	-	108.8	12.3	147.2	46.8	13.6	14.4	0.5	-	34.7	4.2	27.5	16.0	40.2	562.8	427.3
1995	69.4	33.4	12.8	-	116.8	13.2	157.2	49.3	14.4	15.2	0.6	-	36.5	4.4	29.0	16.8	42.3	611.3	468.8
1996	70.9	34.9	13.4	-	124.9	14.0	167.2	51.9	15.1	16.0	0.6	-	38.4	4.6	30.5	17.7	44.4	644.3	694.9
1997	76.4	36.5	14.1	-	133.0	14.8	177.1	54.4	15.8	16.9	0.6	-	40.3	4.8	32.0	18.6	46.5	681.3	524.9
1998	79.9	38.1	14.8	-	141.0	15.6	187.1	57.0	16.6	17.7	0.6	-	42.1	5.1	33.5	19.4	48.6	716.4	553.0
1999	83.4	39.7	15.5	-	149.1	16.4	197.1	59.5	17.3	18.5	0.7	-	44.0	5.3	35.0	20.3	50.7	751.4	581.0
2000	86.9	41.3	16.1	-	157.2	17.2	207.1	62.0	18.1	19.3	0.7	-	45.9	5.5	36.5	21.2	52.8	787.4	609.0
2001	90.5	42.9	16.8	-	165.2	18.0	217.0	64.6	18.8	20.1	0.7	-	47.7	5.7	38.0	22.0	54.9	821.4	636.1
2002	94.0	44.5	17.5	-	173.3	18.9	227.0	67.1	19.6	21.0	0.8	-	49.6	6.0	39.5	22.9	57.0	827.3	665.1
2003	97.5	46.1	18.1	-	181.4	19.7	237.0	69.7	20.3	21.8	0.8	-	51.5	6.2	41.0	23.8	0.0	834.7	693.0
2004	101.0	47.7	18.8	-	189.4	20.5	247.0	72.2	21.0	22.6	0.8	-	53.3	6.4	42.5	24.6	0.0	867.9	721.2

Source: Study Team.

ii. Time Saved

4.126 Table 4.27 presents the vehicle-km in Irbid City for the cases of with and without the project, which was derived from the traffic projections in Section 4.3.6.

Table 4.27 Comparison of Vehicle-kilometer per Day, 1985 and 2000

	Year	Vehicle-km/day 1985	2000
With Project	Radial Roads	259,221	362,642
	Existing Ring Road	59,079	90,528
	New Ring Roads	102,561	173,006
	Total	420,867	626,176
Without Project	Radial Roads	394,336	592,859
	Existing Ring Road	44,300	64,193
	Total	438,636	657,052

Source: Study Team.

Note: Existing ring road is the part of the Boundary Ring under construction at present.

4.127 In order to calculate the total travel time the average operating speeds on each road were assumed as follows, taking into account the relationship between average speeds and traffic volumes.

	1985	2000
Radial Roads	25 km/hr	15 km/hr
Ring Roads	55 km/hr	50 km/hr

4.128 Table 4.28 presents the estimated total travel time for the cases of with and without the project.

Table 4.28 Comparison of Travel Time

(Unit: vehicle-min/day)

	1985	2000
With Project	798,465	1,766,809
Without Project	994,733	2,448,468
Difference	196,268	681,659

Source: Study Team.

4,129 The unit time value of each trip was calculated by type of vehicle on the basis of the annual income and the annual working hours on average.

4.130 The time value for a driver of a private car was assumed to be equal to the average labor productivity in the East Bank, and that for a passenger of a private car or taxi to be the per capita Gross Domestic Product. As for the drivers of taxis and trucks, information from the Ministry of Public Works was used. The results are shown in Table 4.29. The average number of working days were assumed to be 280 days per year.

Table 4.29 Estimated Time Value

(Unit: JD/min in 1978 prices)

Private Car	Driver	0.00565
	Passenger	0.00108
Taxi	Driver	0.00567
	Passenger	0.00108
Trucks	Driver	0.00767

Source: Study Team estimates and Information from the Ministry of Public Works.

4.131 The average number of passengers in a passenger car, is given in Table 4.30, which was derived from our survey.

Table 4.30 Average Number of Passengers

Type of Vehicle	No. of Passengers
Private Car	1.87
Taxi	2.63

Source: Study Team's survey.

Note: Figures include the driver.

4.132 Though time savings for vehicles or freight can be added to those for passengers, only the benefits for drivers and passengers were counted in this Study. The estimated time savings are given in Table 4.31.

iii. Reduction in Vehicle Operating Costs

4.133 Vehicle operating costs are composed of running costs, that depend on distance and speed. The unit running cost by travel speed was estimated for four types of vehicles, as shown in Table 4.32 and Table 4.33.

4.134 The benefit accruing to the reduced operating costs should be calculated by type of traffic, i.e., normal traffic and generated traffic, since only half of the unit benefit should be taken for the generated ones. However, the generated traffic was neglected in this Study so that whole amount of unit benefit can be applied for all the traffic.

4.135 The total reduced operating costs can be obtained by utilizing the total vehicle-km in Table 4.27 and the unit operating costs in Table 4.32 and Table 4.33. The results are shown in Table 4.34.

4.136 There must be a reduction in the cost of idling engine for stationary vehicles to be added to the benefits above, however, it was not accounted for in this Study due to difficulty in assessing the idling time.

Table 4.31 Time Saving Benefit Stream, Alternative I

(Unit: JD 1,000/day in 1978 prices)

Year	Type of Vehicles			
	Private Car	Taxi	Trucks	Total
1985	91.0	83.2	84.3	258.5
1986	98.9	90.5	91.6	281.0
1987	106.2	97.1	104.6	307.9
1988	115.4	106.8	113.7	335.9
1989	125.4	114.7	123.6	363.7
1990	136.4	124.7	134.3	395.4
1991	146.3	133.8	154.0	434.1
1992	159.1	145.5	166.3	470.9
1993	172.9	158.2	180.7	511.8
1994	187.9	171.9	196.5	556.3
1995	201.7	184.5	223.3	609.5
1996	219.2	200.6	242.7	662.5
1997	238.3	218.0	263.8	720.1
1998	255.7	233.9	299.2	788.8
1999	277.9	254.2	325.3	857.4
2000	300.2	275.3	351.3	926.8
2001	326.3	298.5	381.9	1,006.7
2002	340.0	320.2	432.4	1,102.6
2003	380.5	348.0	470.1	1,198.6
2004	413.6	378.3	511.0	1,302.9

Source: Study Team.

Table 4.32 Vehicle Operating Cost for Passenger Cars

(Unit: JD/1,000 km in 1978 prices)

Private Car Cost Items	Cost at Operating Speeds (km/hr) of 55	50	25	15
Fuel Consumption	6.25	6.17	7.38	9.12
Tire Wear	0.11	0.10	0.04	0.03
Lubricants	0.42	0.42	0.53	0.70
Maintenance/Repairs	1.50	1.46	1.21	1.17
Depreciation	9.73	9.97	13.05	14.47
Interest & Insurance	1.93	1.93	1.93	1.93
Total	19.94	20.05	24.14	27.42

Taxi Cost Items	Cost at Operating Speeds (km/hr) of 55	50	25	15
Fuel Consumption	5.35	5.26	6.07	7.43
Tire Wear	0.13	0.12	0.04	0.03
Lubricnats	0.59	0.60	0.77	0.98
Maintenance/Repairs	2.70	2.63	2.21	2.13
Depreciation	1.93	1.98	2.59	2.89
Interest & Insurance	7.01	7.01	7.01	7.01
Total	17.71	17.60	18.69	20.47

Source: Study Team estimates based on information from the Ministry of Public Works.

Table 4.33 Vehicle Operating Cost for Trucks

(Unit: JD/1,000 km in 1978 prices)

Light Truck Cost Items	Cost at Operating Speeds (km/hr) of 55	50	25	15
Fuel Consumption	11.92	11.78	13.71	16.17
Tire Wear	0.23	0.21	0.08	0.05
Lubricants	0.73	0.76	0.99	1.19
Maintenance/Repairs	2.10	2.02	1.62	1.60
Depreciation	5.29	5.47	7.71	9.12
Interest & Insurance	11.28	11.28	11.28	11.28
Total	31.55	31.52	35.39	39.41

Heavy Truck Cost Items	Cost at Operating Speeds (km/hr) of 55	50	25	15
Fuel Consumption	5.04	5.01	5.78	6.85
Tire Wear	10.56	9.63	3.95	2.50
Lubricants	1.42	1.46	1.91	2.31
Maintenance/Repairs	13.90	13.35	10.78	10.58
Depreciation	6.45	6.65	9.41	11.12
Interest & Insurance	14.97	14.97	14.97	14.97
Total	52.34	51.07	46.80	48.33

Source: Study Team estimates based on information from the Ministry of Public Works.

Table 4.34 Operating Cost Savings

(Unit: JD 1,000 in 1978 prices)

Year	Operating Cost by Type of Vehicles				Total
	Private Car	Taxi	Light Truck	Heavy Truck	
1985	169.1	49.5	61.9	-1.0	279.5
1986	132.1	52.9	65.4	-0.2	300.2
1987	192.4	56.0	71.8	0.4	320.6
1988	206.2	60.5	77.2	1.1	345.0
1989	220.1	65.1	86.8	2.1	374.1
1990	227.1	70.7	93.1	2.9	393.8
1991	248.0	74.1	99.6	3.7	425.4
1992	264.4	81.6	106.3	4.8	457.1
1993	281.7	85.2	118.7	6.2	491.8
1994	297.6	91.1	127.0	7.2	524.9
1995	314.2	96.1	135.2	8.4	543.9
1996	333.5	102.4	143.8	9.7	589.4
1997	353.9	109.2	159.7	11.4	634.2
1998	370.2	114.7	169.5	13.6	668.0
1999	392.0	121.6	179.7	14.3	707.6
2000	403.3	124.3	191.8	14.3	733.7
2001	428.8	132.6	204.2	16.1	781.7
2002	447.5	138.6	212.5	17.4	816.0
2003	473.3	146.7	224.4	18.7	863.1
2004	500.1	155.3	236.3	20.1	911.8

Source: Study Team.

4.7.5 Economic Evaluation

4.137 The economic evaluation in this Study has two components. One is to select the best plan from the two Alternatives as described in Section 4.4.4. The other is to examine the economic feasibility of the selected plan by utilizing the project benefit estimated above by method 2.

a. Selection of the Best Alternative Plan by Method 1

4.138 In order to select the superior plan from the two Alternatives, the economic costs and benefits were discounted at the annual rate of 12 percent to be the 1978 present value. The accumulated present values are shown in Table 4.35.

Table 4.35 Accumulated 1978 Present Values by Method 1 in 1978 Prices

(Unit: JD)

	Economic Cost	Economic Benefit
Alternative I	4,046,000	4,766,000
Alternative II	2,818,000	3,313,000

Source: Study Team.

Note: Discount Rate = 12 percent.

The indicators for the economic evaluation are summarized in Table 4.36.

Table 4.36 Economic Indicators by Method 1

	Net Present Worth JD 1,000	B/C Ratio	Internal Rate of Return %
Alternative I	719.1	1.18	16.5
Alterantive II	494.3	1.17	16.0

Source: Study Team.

Note: Discount Rate = 12 percent.

4.139 The economic indicators show that both Alternatives are economically feasible and that Alternative I is slightly more advantageous than Alternative II. Thus, although the differences in B/C Ratio or IRR between the two Alternatives are not large, the Study Team concluded that Alternative I should be selected. The reasons are as follows:

(1) A greater net present worth can be expected.

(2) A more effective framework can be afforded to the city for a planning of land use.

(3) More multiplier effects can be expected by providing better access to the surrounding villages.

b. Project Feasibility by Method 2

4.140 The Ring Roads Project was found to be economically feasible by the above indicators. The benefit used by the above appraisal is certainly suitable for application to the project, but the estimation method used is not a broadly prevailing one. Therefore, the benefit obtained by the more prevailing method, i.e., method 2, was applied below to confirm the economic feasibility of the selected plan.

4.141 The total benefit by this method resulted in JD 5,359,800 as the 1978 present value, at the annual discount rate of 9 percent. The economic benefit-cost ratio was found to be 1.13, the net present worth to be JD 617,500 at the discount rate of 9 percent, and the internal rate of return was 9.9 percent which is higher than the current interest rate of commercial banks in Jordan.

4.142 As for the additional benefits which were not accounted in this Study by method 2, the following can be primarily enumerated.

(1) Time savings for vehicles, freight and assistant operators of goods vehicles.
(2) Operating cost savings from reduced idling of engines.
(3) Reduction in the number of traffic accidents.
(4) Benefits for generated traffic due to the regional development.

Hence, it can be said that the above benefit-cost analysis was conservatively made. Consequently, the feasibility of the Ring Roads project can be economically justified.

4.7.6 Sensitivity Analysis

4.143 The economic sensitivity analysis was undertaken to ensure the economic feasibility of the project by assessing the following alternative conditions involving various uncertainties or risks.

	Construction Cost	Benefit
Case 1	+20%	±0%
Case 2	±0%	-10%
Case 3	+20%	-10%

4.144 Among them, Case 3 is the most conservative or the least favorable one. The analysis was made for the two Alternative Plans as explained in Section 4.4.4. The results are shown in Table 4.37 and Figure 4.28.

Table 4.37 Internal Rates of Return for Sensitivity Analysis

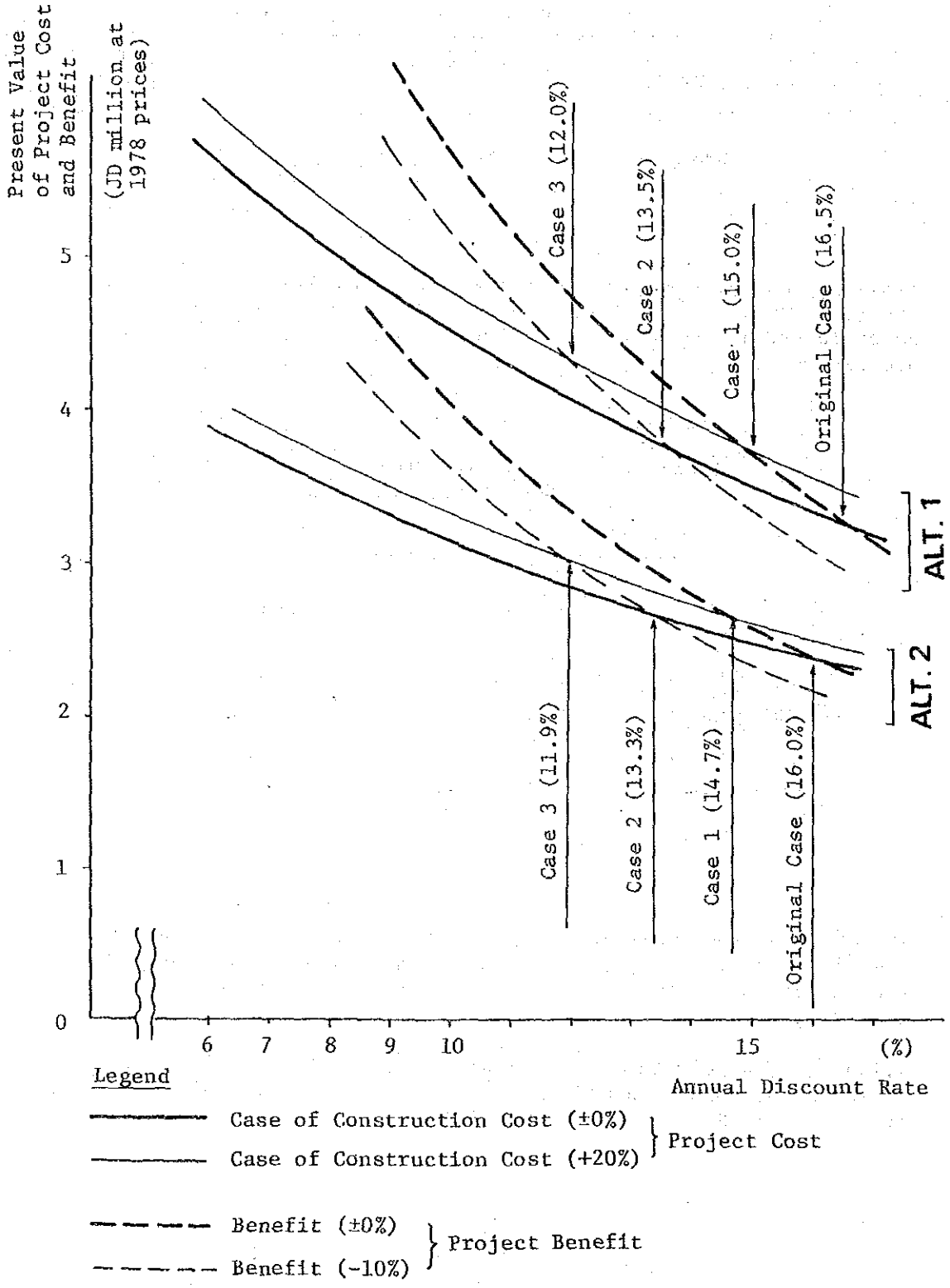
	IRR	
	Alternative I	Alternative II
Case 1	15.0%	14.7%
Case 2	13.5%	13.3%
Case 3	12.0%	11.9%

Source: Study Team.

The share of the construction cost compared to the total economic cost is only 36 percent, at the discount rate of 12 percent, therefore, the variation of benefit is more influential to the IRR than to the construction cost.

4.145 The results above indicate that Alternative I is more advantageous than Alternative II in any case, and that the Ring Roads project is still economically feasible.

Figure 4.28 Sensitivity Analysis



Source: Study Team.

4.8 Further Examination on Design Standards

4.8.1 Introduction

4.146 Some officials in the Ministry of Public Works commented that the design standards used in the Study are different from their standards of the rural primary highway. Their comments are as follows:

	Unit	Recommended Standards by the Study Team	Standards Used by Jordan Government
(1) Lane Width	m	3.3	3.6
(2) Parking Lane Width	m	2.0	3.0

These are good remarks on the design standard, and so we examined these carefully as follows.

4.8.2 Lane Width

4.147 As to the lane width, basis of the comment recommending 3.6 m is the "Geometric Design Criteria for Rural Highways" officially used the Ministry of Public Work. As the title suggests us, it is the standard for the rural highways. Since the Ring Roads are of urban highway, the Criteria are not directly applicable to the Ring Roads. Moreover, even the Criteria allow the highway of 60 km per hour to have the lane width of 3.3 m, if we assume the highway be the secondary road whose design speed on a flat field is 80 km per hour. Thus, it seems that the lane width of 3.3 m is permissible even based on the Criteria.

4.148 As stated in Section 4.5.2, the Team referred to "Master Road Plan 1978-1982" and the Japanese urban "Road Structure Ordinance" in deciding the lane width. Master Road Plan contains the tolerable standards for urban arterial and collectors, which says urban arterial road is tolerable at the width of 3.3 m. And the Road Structure Ordinance suggests that standard width for the urban highway with the design speed of 60 km per hour is 3.25 m. Thus, the lane width of 3.3 m also is permissible based on these references.

4.149 Based on above, it can be concluded that the lane width of 3.3 m is feasible. The Team, however, made further examination by utilizing "A Policy on Design of Urban Highway and Arterial Street, 1973" by AASHO (American Association of State Highway Officials) and the Road Structure Ordinance. The AASHO's Policy suggests that the lane width of 3.66 m is recommended to all types of highways and consequently that the urban highway is recommended to have the width

of 3.66 m. And, the Road Structure Ordinance suggests that if the urban highway is design for the traffic of 80 km per hour it should have the lane width of 3.5 m. These imply that the Jordan Government reckons that a urban highway should have a high level design standard. The lane width of 3.6 m is recommendable. Therefore, the selection between 3.3 and 3.6 m depends on the preference of the Jordan Government.

4.8.3 Parking Lane

4.150 As for the parking lane width, the basis of the comment recommending 3 m also is the Criteria. As suggested before, it is the standard for the rural highways, being not applicable to Ring Roads which are urban highways. In addition, Master Road Plan says the tolerable standard of the shoulder width for the urban arterial highway without access control is 1.8 m. The Road Structure Ordinance also recommends the shoulder width of 1.25 m for urban arterial highways. Thus, the shoulder width of 2 m is reasonably enough.

4.151 However, from the viewpoint of parking lane the story is different. The Master Road Plan recommends the curb-parking-lane width of 2.4 m for urban arterial highways, and the Road Structure Ordinance recommends the width of 2.5 m with an allowance down to 1.5 m. Thus, 2.4 m seems to be reasonable for the parking lane width.

4.152 As a conclusion, if we regard the part concerned as the shoulder of the highway 2.0 m is enough, and if we regard the part as a parking lane as we assumed originally 2.4 m is required. This will be the issue to be decided by the Government of Jordan.

4.8.4 Conclusion

4.153 As discussed above, the decisions both on the lane width and parking lane width are left in the hand of the Government of Jordan. So, at this stage, it is necessary to examine the feasibility of the new design standard. Since the design standards of 3.3 m lane width and 2.0 m parking lane width was already examined, the another set of design standard should be examined here.

4.154 The Team estimated the cost of the Ring Roads project with the design standard of 3.6 m lane width and 2.4 m parking lane width, and examined its economic feasibility. Its cost was estimated at JD 3.0770 million for the First Stage (1982 to 1984) and JD 0.3350 million for the Ultimate Stage (1989). Therefore, the total project cost will reach JD 3.4120 million at 1978 prices accounting for 2.9 percent increase of the project cost when compared with the costs estimated in Section 4.6.4 of this Volume.

4.155 On the basis of these costs, an economic study was undertaken for the Alternative I which includes the construction of the Outer Ring, using benefit estimation by Method 1 depicted in Section 4.7.4. The IRR in this case is found to be between 15 percent and 16 percent and interpolation shows it to be about 15.9 percent (original case: 16.5 percent). Therefore, the Ring Roads project with modified design standard is still feasible.

4.9 Conclusion and Investment Schedule

4.9.1 Conclusion and Recommendations

a. Concluding Remarks on the Ring Roads Project

4.156 The Ring Roads project, as studied by the Study Team, involved the following sections:

(1)	Boundary Ring Road	12.3 km
(2)	Outer Ring Road	7.7
(3)	Two Connecting Roads Between the Boundary Ring and the Outer Ring	2.0
		22.0 km

4.157 The results of this Study show that the Ring Roads are definitely needed and are economically feasible. The conclusions of the study are summarized below.

(1) The Boundary Ring Road is planned as a four-lane road, but all the Rings should be open to traffic as two-lane roads by 1985, except for the section between Route 11 to Jerash and Route 23 to Ajlun, which is required to have four lanes by 1985.

The section of the Boundary Ring between Baghdad Street and Route 23 to Beit Ras should be widened to four lanes by 1990.

(2) The construction of the Boundary Ring should be initiated at the section between Baghdad Street and Route 23 to Beit Ras in order to support the Industrial Estate Project.

(3) The Outer Ring Road is planned as a half ring road at the east side of the city with two lanes.

The widening of the Outer Ring to four lanes is not necessary for the coming two decades, if the Boundary Ring is widened.

(4) The Connecting Roads are planned as a two-lane road for Road A and as a four-lane road for Road B. Road B should be open to traffic as a two-lane road by 1985 and be widened to four lanes by 1990.

(5) Even though there exist such sections as the west part of the Boundary Ring or the Outer Ring Road which do not need four lanes for the coming two decades, it is recommended to acquire enough land at all the sections for possible future road widening as well as for creating better residential area.

(6) The route and typical cross sections of the project are shown in Figure 4.18 and Figure 4.19. The Government of Jordan, however, has to make decision on two issues: (1) whether the modified standard of 3.6 m or the original standard of 3.3 m should be taken up as a lane width and (2) whether the modified standard of 2.4 m or the original standard of 2.0 m should be taken up as a parking lane width.

(7) For the intersections of Ring Roads with main roads, it is recommended that in future traffic signals should be installed instead of rotary type intersections. This is illustrated in Figure 4.21.

(8) The total construction costs in 1978 prices were estimated to be JD 2,173,500 for the Boundary Ring Road, JD 830,600 for the Outer Ring Road, JD 224,800 for the two Connecting Roads (see Tables 4.17 and 4.18), when the original standards of the lane and the parking lane widths are adopted. If the modified standards are adopted, JD 2,312,200 for the Boundary Ring Road, JD 864,300 for the Outer Ring Road, and JD 235,500 for the two Connecting Roads.

(9) The total project cost in 1978 prices was estimated to be JD 3,228,900, of which the foreign portion is JD 1,536,700, when the original standards are adopted. If the modified standards are adopted, it will be JD 3,412,000.

(10) As a result of the economic study, the benefit-cost ratio of the project is 1.18 at the discount rate of 12 percent, the net present worth is JD 719,100 and the internal rate of return is 16.5 percent, when the original standards are adopted. If the modified standards are adopted, its IRR is 15.9 percent.

4.158 The road networks recommended for the years 1985 and 2000 are shown in Figure 4.16. Among them, the following projects are highly recommended, in addition to the Ring Roads project.

(1) Projects for the Period till 1985:

1) Inner Ring:

The east part of the ring which is now under construction should be completed with two lanes.

2) The Road Near the Industrial Area Connecting Three Rings:

The road near the existing industrial area connecting the three ring roads should be completed with two lanes in order to support the development of the industrial area and the Industrial Estate project.

(2) Projects for the Period After 1985:

1) Completion of the Inner Ring:

The northwest part of the ring should be completed at the earliest possible time.

c. Other Recommendations

4.159 In addition to the above, the following are recommended:

(1) It is recommended to install traffic signals at the main intersections in the city. This will be helpful for reducing traffic accidents and congestion.

(2) Parking of motor vehicles should be prohibited in certain streets to increase the road capacity, and several parking areas in the city center should be provided. A toll system could be introduced.

(3) It is also recommended that a bus corporation should be established to operate on the three ring roads. The heavy dependence on taxis for public transportation will be one of the causes of traffic congestion in the near future.

(4) A comprehensive city plan for the whole city area should be prepared as soon as possible, the purpose being to help the implementation of the project with regard to road construction. It would be more effective and easier if the plan is approved before the project site is fully urbanized.

(5) Referring to the above suggestion, it is also recommended that a study be conducted on the possibility of a Greater Outer Ring Road project, i.e., the construction of a new larger ring road connecting the surrounding villages of Irbid. This project would be effective for the further development of the Greater Irbid Region.

4.9.2 Investment Schedule

4.160 For the construction work, it is assumed that the executive agency will select the contractor by international bidding.

a. Work Plan

4.161 The construction work of Alternative I, recommended as the result of economic study in Section 4.7, is designed below. In designing the work plan, the number of average working days per year (365 calendar days) is assumed to be 260 days. Work plan is:

(1) Construction (two stages):

1) First Stage (completed by 1985)

Boundary Ring Road
Outer Ring Road
Connecting Road A
Connecting Road B

2) Ultimate Stage (completed by 1990)

Eastern part of Boundary Ring Road
(widened to four lanes)
Connecting Road A (widened to four lanes)

(2) Traffic lanes:

The traffic projection in Section 4.3 and the preliminary design in Section 4.5 indicate two lanes for the Boundary Ring Road, Outer Ring Road, Connecting Road A and Connecting Road B in the first stage, and four lanes to the eastern part of Boundary Ring Raod and Connecting Road B in the ultimate stage.

b. Construction Plan

4.162 Before beginning construction it is necessary to carry out such pre-construction preparatory works as topographical survey, soil investigation, review of the feasibility study detailed design, land acquisition, and financial procurement. The period required for such preparatory procedures is estimated to be 36 months. The detailed design including review of the feasibility study will take about fourteen months.

4.163 During the period when land acquisition completed, the contract for construction can be approved and awarded. Mobilization for construction can begin after the contract is awarded. The construction period is estimated to be about twenty-two months for the First Stage, and about twelve months for the Ultimate Stage.

c. Investment Schedule

4.164 According to the above mentioned outline, the investment schedule is designed as shown in Figure 4.29. Construction schedule analysis of the first stage is shown in Figure 4.30.

Figure 4.29 Overall Investment Schedule of Ring Roads of Irbid, 1980 to 1990

(Unit: JD 1,000 in 1978 prices)

Description \ Year			1980	1981	1982	1983	1984	1985	1986	1989	1990
Engineering				———							
Land Acquisition					———						
Contractor's Prequalification					—						
Tender					—						
Construction: 1st stage						(45%)	(55%)				
Ultimate stage										(100%)	
Investment Amount	Original Case	F.C.				598	732			207	
		L.C.			819	343	419			111	
	Modified Case 1/	F.C.				655	799			216	
		L.C.			841	352	430			119	
Remarks					(Land & Comp.)	(Construction)				(Construction)	

Source: Study Team.

Note: 1/ This is estimated using the modified design standards stated in Section 4.8.

Figure 4.30 Construction Schedule Analysis

(Unit: Months)

1st Stage (Road Length: 22,000 M) - Alternative I -

Main Works	Year / Qunt. / M	1983 2 4 6 8 10	1984 2 4 6 8 10	2 4 6 8 10	Production Rate per month
Move on Site	-	3			-
Relocation of Obstacles	-	2			-
Earth Work	207,300M^3		10		21,000 M^3
Subgrade Preparation	146,000M^2		6		24,000 M^2
Base Course	47,450M^3		6		7,900 M^3
Asphalt Surface (t=10CM)	225,700M^2		6		38,000 M^2
Bridge (R.C. slab)	128M^2		6		-
Finish Roadway	-		10		-

Source: Study Team.