

Where: r = Rainfall intensity (mm/hr)

$a = 5,006$ for return period of 10 years

$a = 6,635$ for return period of 50 years

t = Time of concentration (min)

$$t = \frac{L}{0.6 \cdot 20 \cdot I \cdot 60}$$

Where: I = Water surface slope

L = Length (m) of water flow

5.04.3 Estimate of Discharge

Discharges of the rivers crossing A and D routes are calculated by the following Mononobe formula using a map of 1 : 5,000 scale.

$$Q = \frac{1}{3.6} \cdot f \cdot A \cdot r.$$

Where: Q : Discharge (m^3/s)

f : Run-off coefficient (0.15 or 0.25)

A : Catchment area km^2 (ref. Annex V-17)

r : Rainfall intensity (mm/hr) with the return periods of 10 years or 50 years.

Run-off coefficient f is assumed as follows;

(a) For up to km 30 along A route

((1) - (13)) $f = 0.25$

(b) For other rivers beyond the above area, $f = 0.15$,

because of sandy soil and variable flat watercourses.

For some rivers crossing B and F routes on which the above formula is not applicable because a map at a scale of 1 : 5,000 is not available for these areas, discharges are estimated by specific run-off curves. The specific run-off curves, which are developed by a regression analysis using the data of rivers for A and D routes, are shown in Annex V-18. The result and data is shown in Annex V-19.

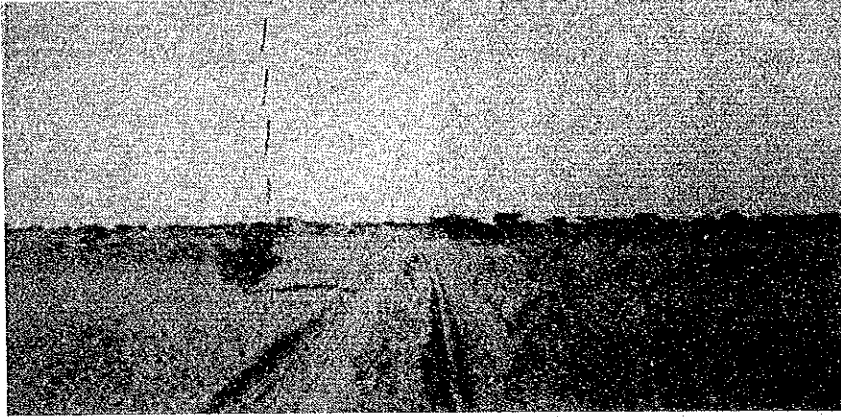


Photo 1 Tracks (at km 4 from El Obeid)

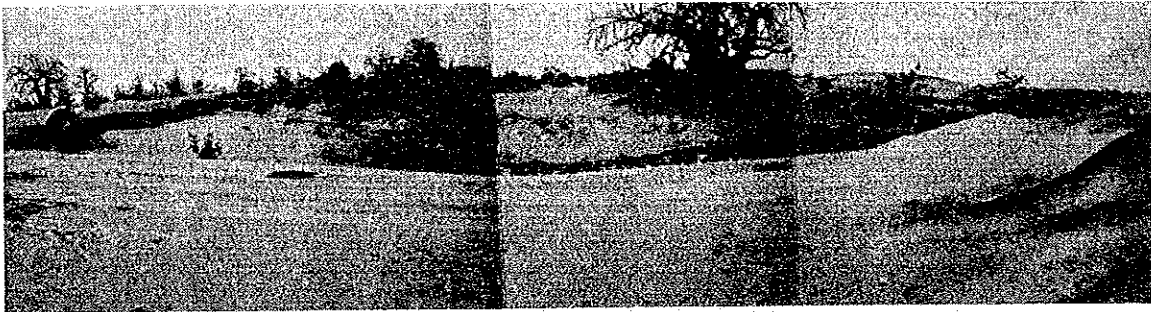


Photo 2 Existing Submergible Bridge of K. El Mulbas
(at km 16 from El Obeid)

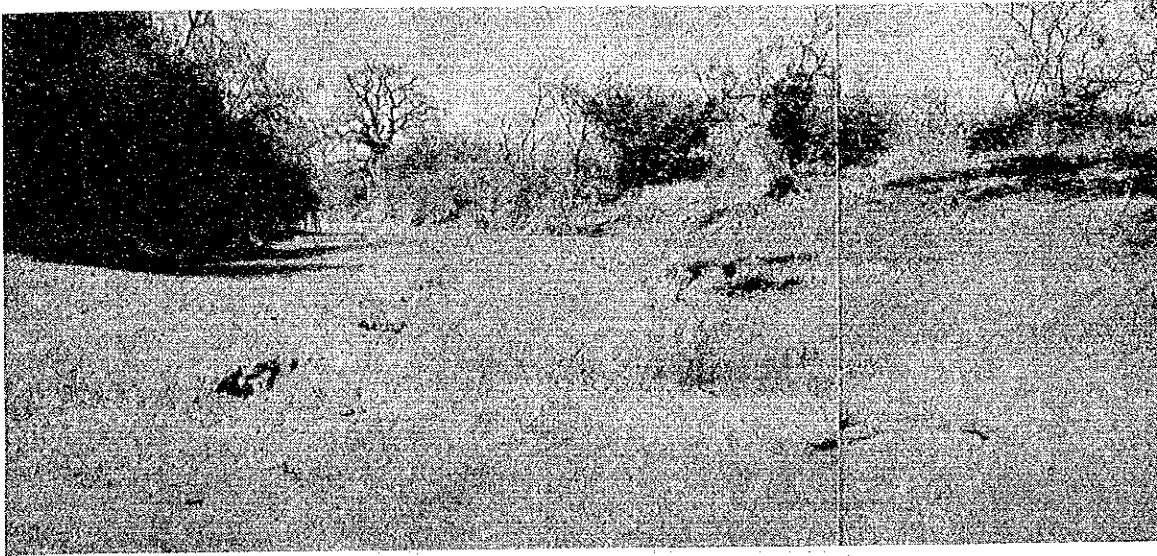


Photo 3 K. El Baggara in Dry Season
(at km 25 from El Obeid)

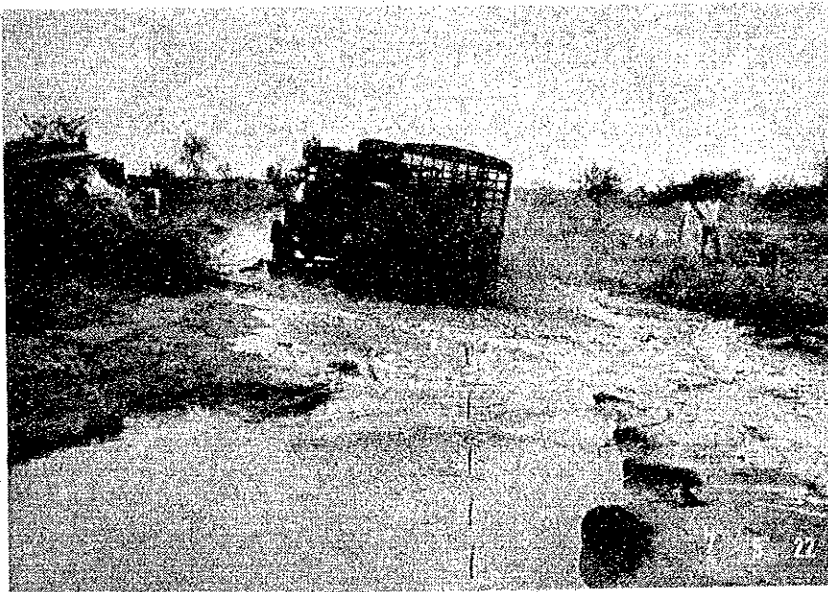


Photo 4 K. Nawa in Rainy Season
(at km 55 from El Obeid)

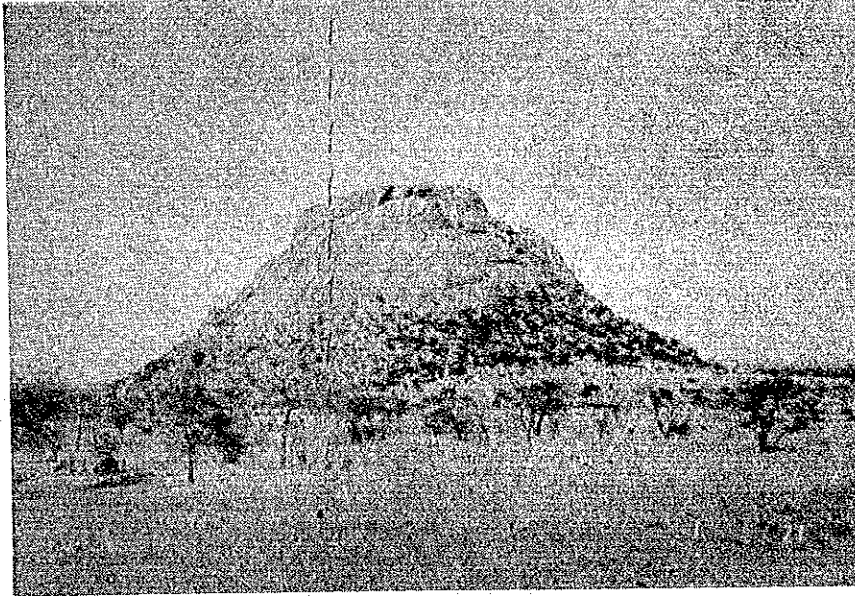


Photo 5 J. El Ain (at km 28 from El Obeid)

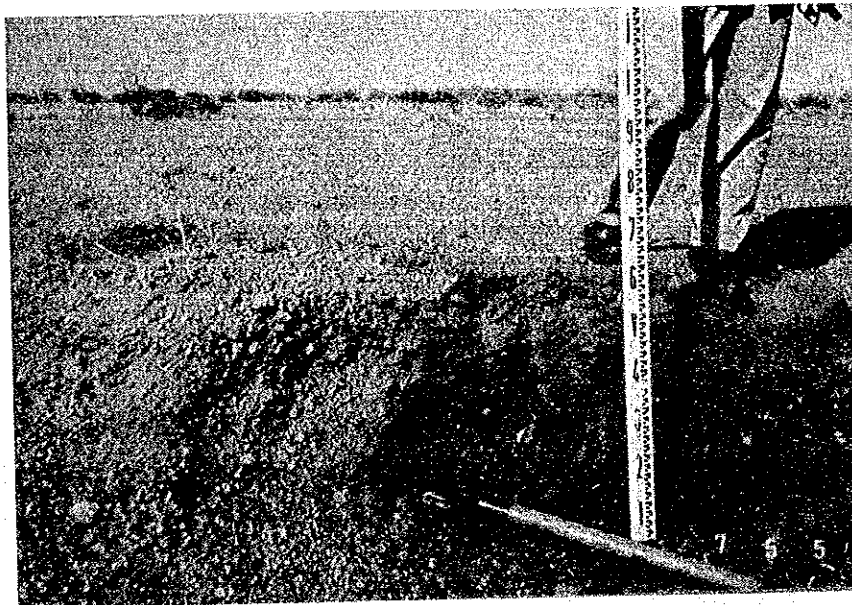


Photo 6 A Borrow Pit (at km 16 from El Obeid)

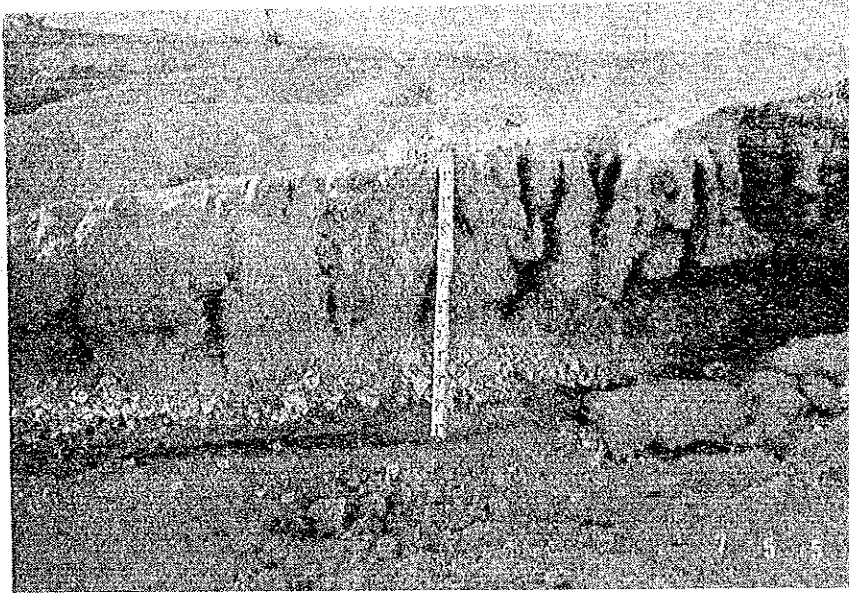


Photo 7 Soils at a Watercourse
(at km 7 from El Obeid)



Photo 8 Black Cotton Clay in Dry Season
(at km 7 from Rahad)

CHAPTER VI

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6.00	TRAFFIC STUDIES 6- 1
6.01	TRANSPORT SYSTEM IN THE PROJECT INFLUENCE AREA . . . 6- 1
6.02	FIELD SURVEYS 6- 7
6.03	RESULTS OF TRAFFIC ANALYSIS . 6-11
6.04	TRANSPORTATION COST 6-33

6.00 TRAFFIC STUDIES

6.01 Transport System in the Project Influence Area

6.01.1 General Description

The project influence area is served by rail, road and air routes which connect the area with the rest of the country, as shown in FIG. VI-1 which illustrates the overall transport network. El Obeid is the centre of transport as well as of socio-economic activities in the western part of the Sudan and thus plays an important role in the region.

Railways link the project area with Khartoum and Port Sudan in the east, Dubeibat and Nyala in the west and other important regional centres in the south. An air route connects El Obeid and Khartoum. Major inter-regional roads linking the project area with other regions are:

- to the north; El Obeid - Bara - Khartoum,
- to the west; El Obeid - En Nahud - El Fasher or Nyala,
- to the east; El Obeid - Um Ruaba - Kosti - Wad Medani-
Khartoum,
- to the south; El Obeid - Dubeibat - Dilling - Kadugli,
Um Ruaba - El Abbasiya and
Rahad/Semeih - Dilling - Kadugli/Nuba
Mountain

Among the roads listed above only two sections, namely

Khartoum - Wad Medani and Dubeibat - Dilling, are paved while the others are earth roads. As many of these earth roads are merely tracks and are not properly maintained, difficult driving conditions are often experienced. During the rainy season traffic is even cut off completely in some sections.

6.01.2 Roads

The road network in the project area, as shown by FIG. VI-2, is basically composed of two trunk routes, the southern route along the railways linking El Obeid, Rahad and Um Ruaba, the northern route directly linking El Obeid and Um Ruaba and the various feeder tracks branching off from the trunk routes. Of the entire road network in the area only some urban streets and the road to the airport in El Obeid are paved.

Generally, the southern route along the railways is passable throughout the dry season. When the sections of cohesive soils become muddy in the rainy season, traffic is greatly impeded and often stopped, particularly in the section between Um Ruaba and Semeih. Then, the northern route and/or other small tracks in qoz areas, which are less affected by rainfall, are utilized. Existing conditions of the roads in the area are described in detail in 5.01, CHAPTER V.

Given such road conditions, light vehicles, except those of four-wheel drive, cannot pass on these roads. Trucks with loading capacities of 6 to 11 tons prevail in the inter-

regional traffic. Donkeys and camels are also popular traditional means of transportation for shorter distances.

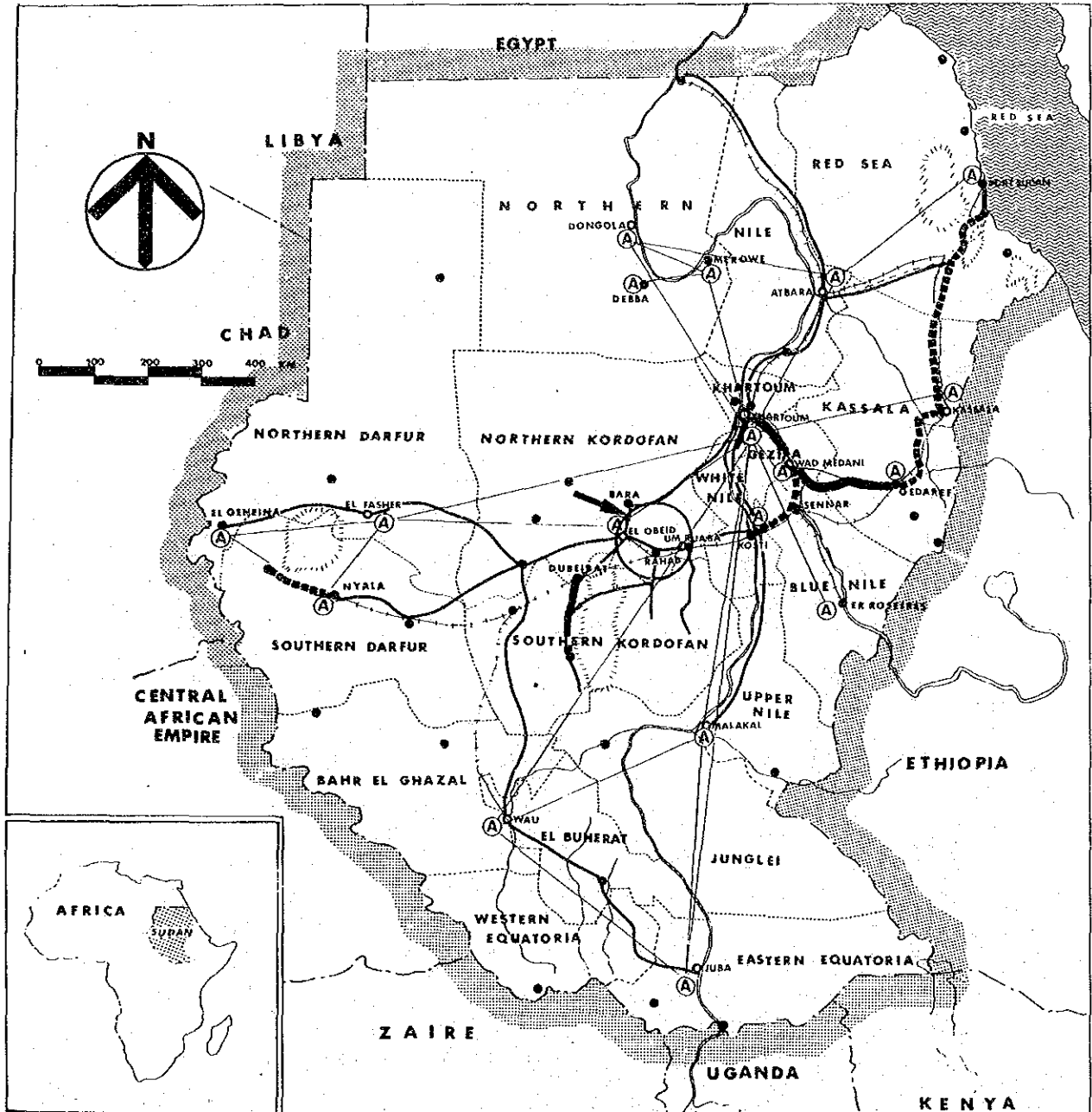
Inter-urban bus services are available only between El Obeid and Rahad, once daily. The buses are always fully occupied and cannot meet the demands of the people. Most of the passengers, therefore, hitch rides on trucks together with goods. In El Obeid town taxis and buses serve the area relatively well, whilst only a small number of taxis is available in Um Ruaba, and neither type of vehicle is available in the other small towns.

6.01.3 Railways

A trunk line linking El Obeid, Rahad, Um Ruaba and four other stations with Khartoum and another line branching off at Aradeib and leading to Nyala compose the railway network in the project area, as shown in FIG. VI-2.

The railways are single track of narrow gauge with 75 lb/yd rails laid on lateritic embankments. Although design speed is 60 km/hr, trains actually operate at 30 km/hr for passenger trains and 25 km/hr for freight trains. It is apparent the railway operation faces great difficulties which often cause delays in schedules due to obsolete equipment and shortage of replacement of parts. Nevertheless, the railway plays a very important role in transporting imports and exports, various consumer goods and passengers. It is reported that the El Obeid - Khartoum section, which passes

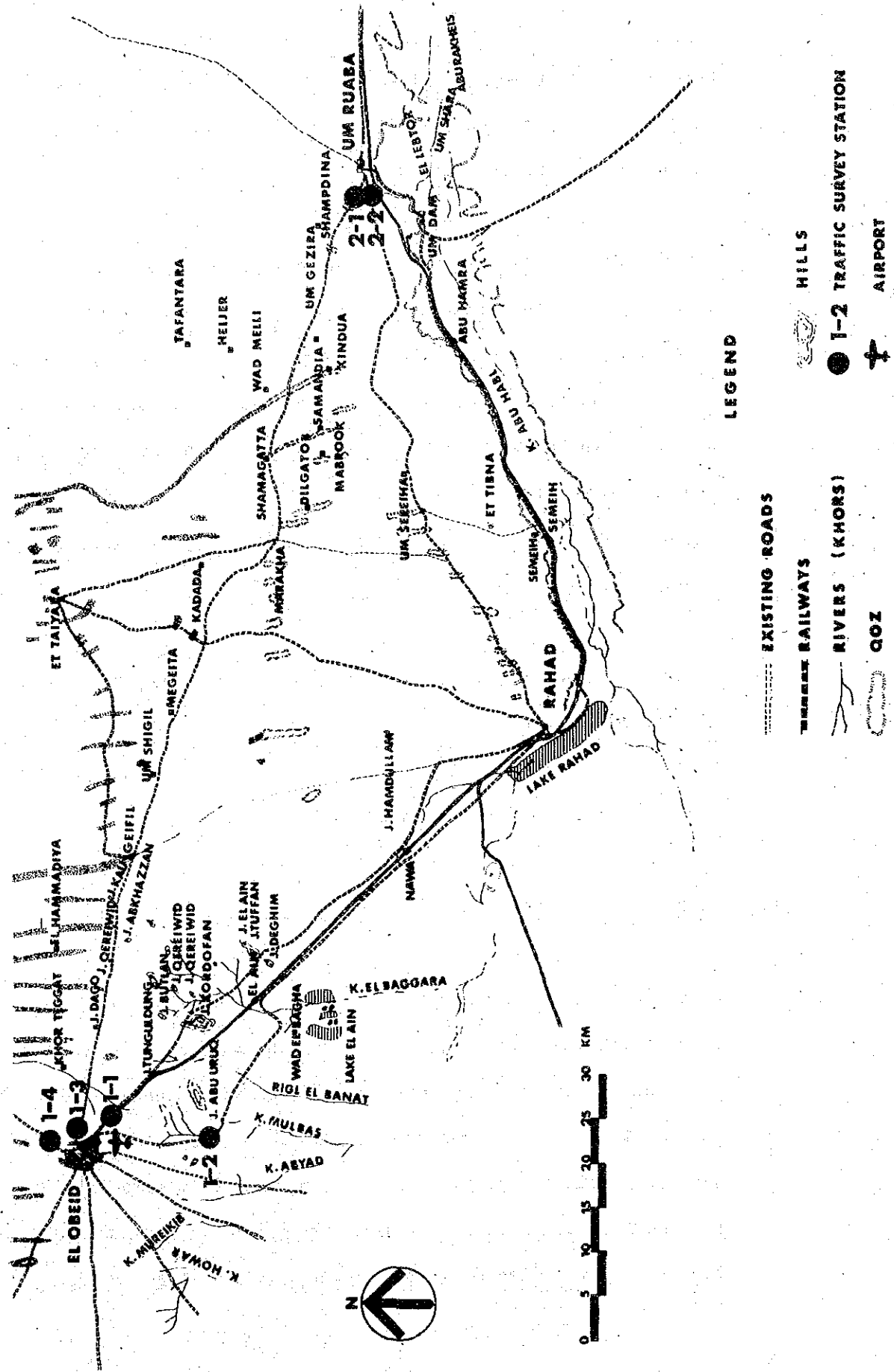
FIG.VI-1 TRANSPORTION NETWORK, SUDAN



LEGEND

- | | | | |
|--|--------------------------|--|------------------------|
| | PAVED ROADS | | INTERNATIONAL BOUNDARY |
| | UNDER CONSTRUCTING ROADS | | PROVINCIAL BOUNDARY |
| | EARTH ROADS | | MOUNTAINS |
| | RAILWAYS | | PROJECT AREA |
| | AIRPORTS | | |

FIG. VI-2 EXISTING TRANSPORTATION NETWORK IN THE PROJECT AREA



several major towns such as Kosti and Wad Medani, is ranked next to the Port Sudan - Khartoum section, the main artery of the country in volume of traffic.

Between El Obeid and Khartoum a passenger train operates daily in each direction. Express and ordinary trains run twice and five times a week, respectively. Passenger train daily service is also available between Khartoum and Nyala and passes Um Ruaba and Rahad in the area. Three express trains and four ordinary trains run weekly. A passenger train is composed of five different classes of coaches, namely sleeper, 1st, 2nd, 3rd and 4th class.

Freight trains are operated three to five times weekly in each direction both on the El Obeid - Khartoum line and the Khartoum-Nyala line. During the peak shipping period of agricultural products, frequencies of service double.

6.01.4 Airways

El Obeid airport contains two 40 m wide runways, one is 1,800 m and the other, 1,300 m long. The latter is seldom used and is now being reconstructed as noted in Annex IV-13. The taxiway is 163 m long and 23 m wide. The runways and the taxiway are paved with gravel. The air terminal, fire facilities, storage facilities, etc. are all very old and telecommunication facilities are inadequate. There are no night lighting facilities.

A regular flight is operated once daily between El Obeid and Khartoum. A Fokker 27 with 36 seats and a Boeing 737 with 101 seats are in service, and the latter is operated every Friday and Saturday. A Boeing 737 between Khartoum and El Fasher and a Fokker 27 between Khartoum and Nyala via El Fasher are also operating by way of El Obeid. These flights are usually full, although delays and cancellations occur often.

6.02 Field Surveys

In order to study the traffic and its freight and passenger characteristics, the following field surveys were carried out.

6.02.1 Road Traffic Survey

i. Type of Surveys Conducted

Traffic count and road-side interviews were conducted, including an origin and destination (O-D) survey, and other items on traffic characteristics were covered. Survey sheets used for the surveys are attached in Annexes VI-1 and VI-2.

ii. Period of Survey

As the traffic level in May corresponds closely to the annual average for 1976, the dates of the surveys were chosen as follows:

El Obeid May 9 - 15 (7 days)

Um Ruaba May 21 - 24 (4 days)

iii. Survey Stations

Four stations in El Obeid and two stations in Um Ruaba were selected for the traffic survey as shown in FIG. VI-2.

iv. Survey Method

Surveys were conducted for 24 consecutive hours. However, at the 1-4 survey station in El Obeid and 2-1 in Um Ruaba where no traffic was recorded during night-time hours for the first two days, surveys from 19:00 to 7:00 hours were omitted. From two to five surveyors were assigned to each station according to the traffic volume at each. Vehicles passing the stations were stopped and interviewed.

v. Items of Survey

To determine the traffic volume, the actual number of vehicles was counted by vehicle type and by hour as shown in Annex VI-1. The items surveyed included-(1) Time of day interviewed, (2) Vehicle type, (3) Make of vehicle, (4) Years in service, (5) Origin of journey, (6) Destination of journey, (7) Travel time, (8) Capacity, (9) Number of passengers aboard, (10) Number of wheels, (11) Loading capacity, (12) Major type of commodities loaded, (13)

Tonnage of commodities loaded, (14) Fuel used and (15) Estimated fuel consumption. These questions were asked during road-side interviews as shown in Annex VI-2.

vi. Adjustment of the Number of Vehicles Surveyed

As it was observed, during the survey, that some vehicles did not stop at the stations (approximately 10% of the number of vehicles surveyed for each station) and some bypassed the stations (approximately 20 to 40% depending on the station), the number of vehicles actually surveyed was adjusted and enlarged to a realistic number in the course of data processing.

vii. Additional Survey

In order to survey traffic composition on paved roads in the Sudan, an additional 24-hour traffic count was conducted at a point 10 km from Khartoum on Wad Medani road for two days, May 30 and 31. The results are shown in Annex IX-1 of CHAPTER IX.

6.02.2 Railway Traffic Survey

i. Type of Surveys Conducted

Interviews for both origin and destination were carried out for passengers only as shown in Annex VI-20.

Freight traffic was surveyed at the headquarters of the Sudan Railways in Atbara and at the stations of El Obeid and Um Ruaba, either by statistics or interviews with relevant officials.

ii. O-D Survey for Railway Passengers

- a) Survey Period: May 17 - May 21 (5 days)
- b) Places of Survey: El Obeid and Um Ruaba Stations, and coaches in operation.
- c) Survey Method: 5 interviewers were assigned to interview passengers, either waiting at the stations or aboard the trains.
- d) Items of Survey: Origin and destination of journey, size of group, class and purpose of trip.
- e) Trains Surveyed: All trains passing either station during the survey period.
(7 trains)

iii. Railway Statistics Survey

Statistics of freight traffic handled at relevant stations and passenger ticket sales were surveyed. Data showing the origin and destination of the traffic could not be obtained.

6.03 Results of Traffic Analysis

6.03.1 Zoning

The zones used for traffic analysis herein are the same as those used in Chapter IV. In the field surveys, 75 places for road vehicles and 56 places for railway passengers were recorded as origin or destination places. These places were integrated into 10 zones in the direct project influence area and 15 zones in the rest of the country. The major town or village of each zone was chosen as the zone centre. FIG. VI-3 shows the zoning map.

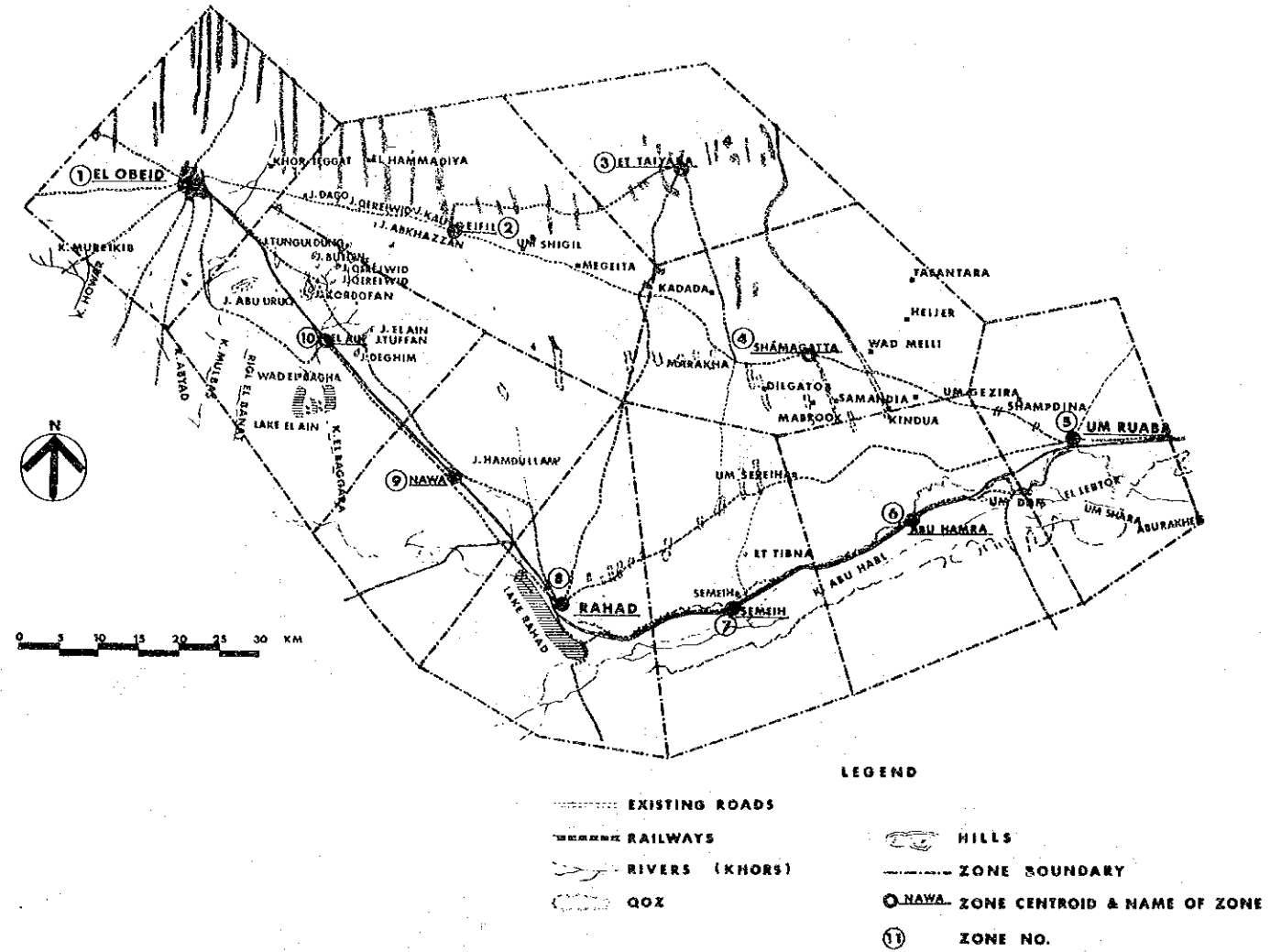
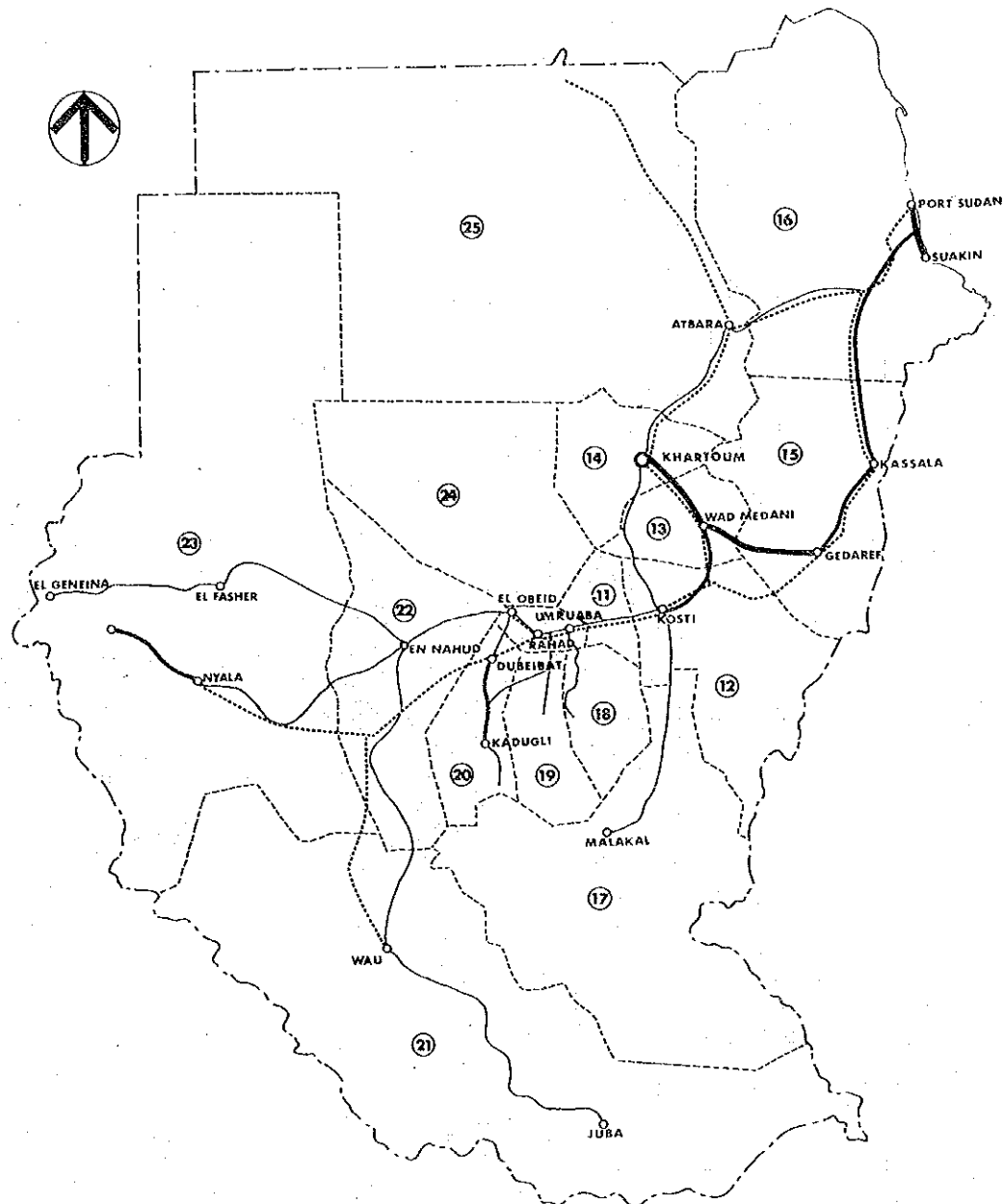
6.03.2 Road Traffic

i. Traffic Volume on the Roads in the Project Area

The average daily traffic at each survey station was estimated as shown in Table VI-1 for the 4 stations around El Obeid and the 2 stations around Um Ruaba. Details are shown in Annexes VI-3 to VI-6. It was assumed that the traffic level in May is slightly less than the average of the year, judging from the commodity movement at El Obeid station and the El Obeid crop market which are shown in Annexes VI-10 and VI-11. However, due to the shortage of data for adjustment, the average daily traffic (ADT) of the survey period was regarded as the annual average daily traffic.

FIG. VI-3

ZONE MAP AND ROAD NETWORK



ZONE NUMBER AND NAME

1 EL OBEID	11 TENDELT	21 WAU-JUBA
2 GEIFIL	12 KOSTI-SENNAR	22 EN NAHUD
3 ET TAIYARA	13 WAD MEDANI	23 NYALA
4 SHAMAGATTA	14 KHARTOUM	24 BARA
5 UM RUABA	15 KASSALA	25 ATBARA
6 ABU HAMRA	16 PORT SUDAN	
7 SEMEIH	17 MALAKAL	
8 RAHAD	18 EL ABBASIYA	
9 NAWA	19 NUBA MOUNTAIN	
10 EL AIN	20 KADUGLI	

TABLE VI-1 AVERAGE DAILY TRAFFIC, EL OBEID-UM RUABA ROAD

(May, 1977)

Area	E L O B E I D								U M R U A B A			
	1-1		1-2		1-3		1-4		2-1		2-2	
Vehicle Type	*	%	*	%	*	%	*	%	*	%	*	%
Van, Pick-up	1.0	1.8	4.5	10.0	1.1	3.3	8.8	30.9	4.8	12.6	0.9	0.8
Medium Truck	50.6	93.7	38.7	86.6	29.6	91.2	13.7	48.1	33.3	87.4	108.6	96.2
Heavy Truck	2.2	4.1	0.4	0.9	1.8	5.5	0.6	2.1	0.0	0.0	3.0	2.7
Bus	0.2	0.4	1.1	2.5	0.0	0.0	5.4	18.9	0.0	0.0	0.3	0.3
Total	54.0	100.0	44.7	100.0	32.5	100.0	28.5	100.0	38.1	100.0	112.8	100.0
Day Time (7:00-19:00)	42.6	78.9	30.9	69.1	22.9	70.5	25.5	89.5	38.1	100.0	62.7	55.6
Night Time (19:00-7:00)	11.4	21.1	13.8	30.9	9.6	29.5	3.0	10.5	0.0	0.0	50.1	44.4

Note: 1) Location of survey stations are shown in FIG. VI-2.

* Denotes number of vehicle.

Due to the poor road conditions in the area, light vehicles are seldom seen, and trucks embrace the largest percentage of the traffic, from 50 to 90% of the total traffic, at any station. Light vehicles used are mainly four-wheel drive vans and pick-ups. Cars and taxis are utilized in the urban area only.

Although actual statistical data are not available, there is a tendency for traffic to lessen on Fridays compared to other days, as shown in Annexes VI-3 and 4. Hourly distribution of traffic, as summarized in Annexes VI-7 and VI-8, indicates that there is more traffic in the morning and in the evening, both in El Obeid and Um Ruaba. The peak hour is between 17:00 and 18:00, and the peak ratio is approximately 10%.

FIG. VI-4-1 shows traffic in the area on major roads during the dry season and was arrived at by estimating the course of the O-D traffic by survey station. The southern (El Obeid-Rahad-Um Ruaba) road is utilized most heavily, and the ADT is about 130.

During the rainy season (June to September), however, the above-mentioned road becomes muddy and the traffic is interrupted to a large extent for quite long periods. Many vehicles then divert to the tracks in qoz areas, and particularly to the northern (El Obeid-Shamagatta-Um Ruaba) road. FIG. IV-4-2 shows the traffic movement pattern during

FIG. VI-4-1 TRAFFIC FLOW ON ROADS IN DRY SEASON, 1977 (Vehicles per day)

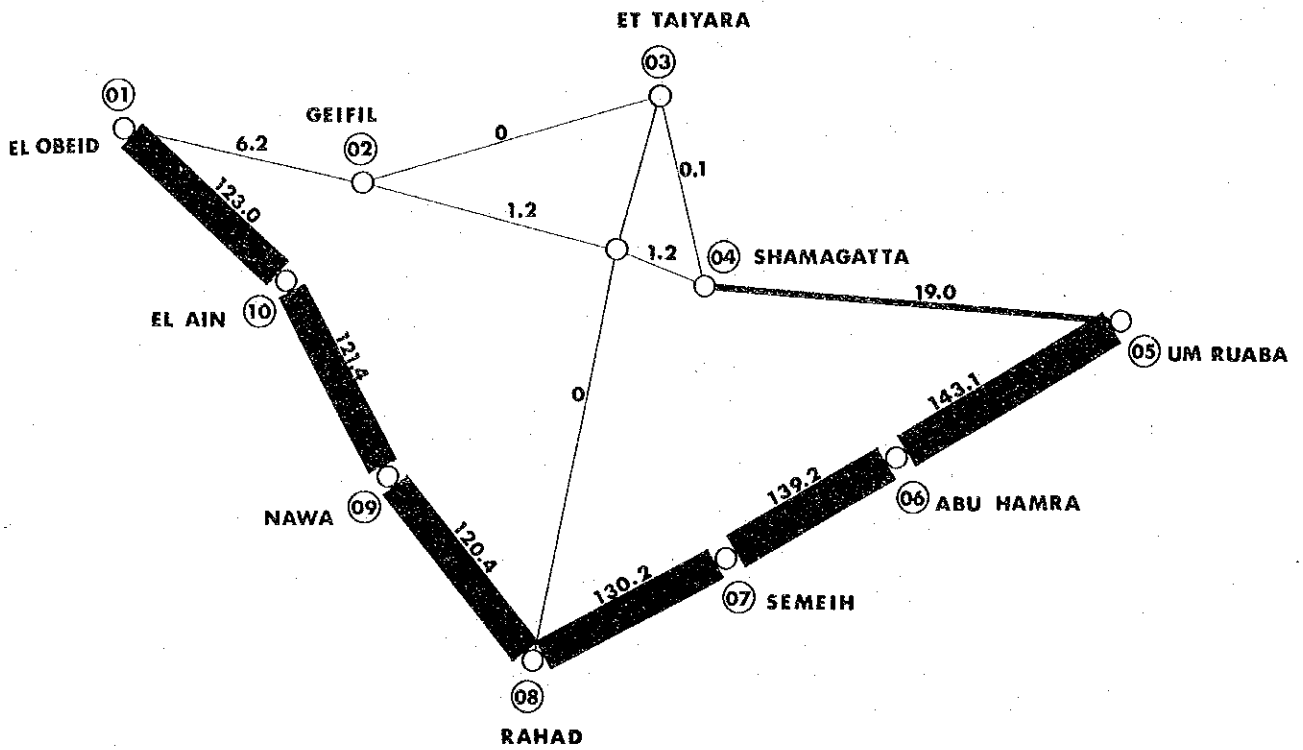
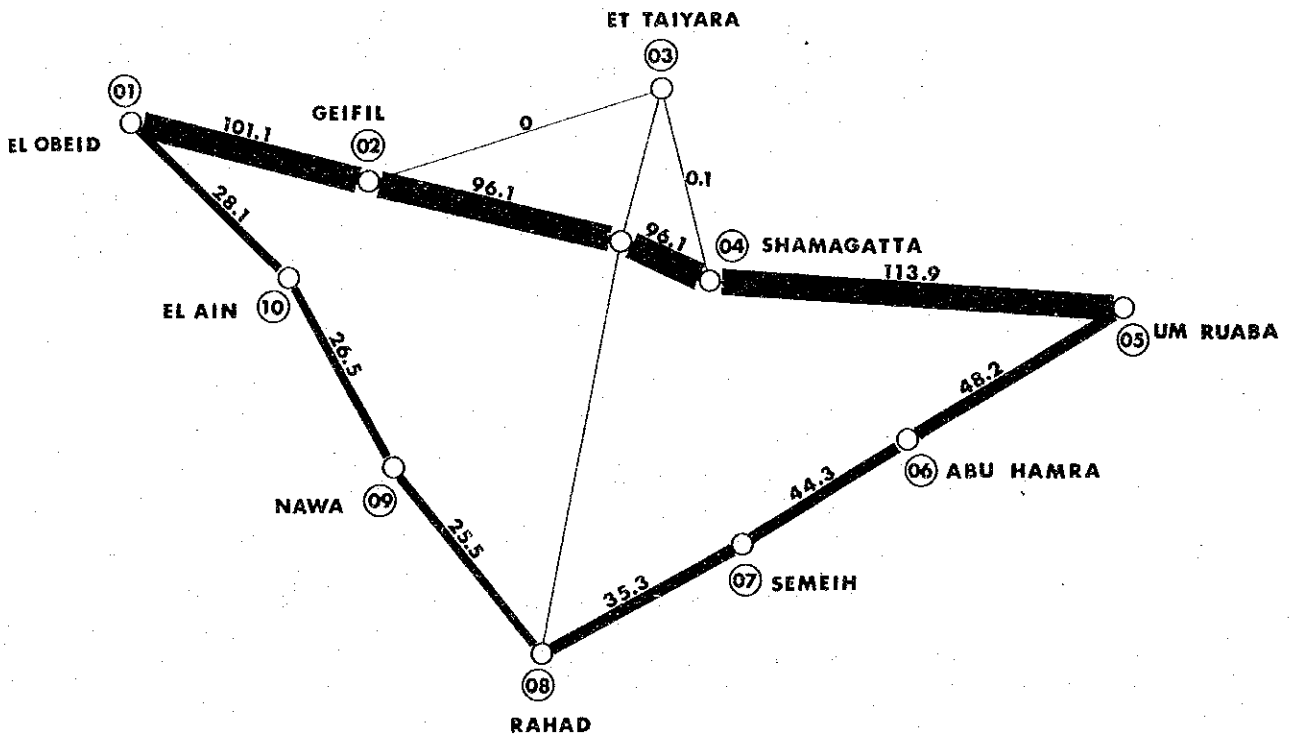


FIG. VI-4-2 TRAFFIC FLOW ON ROADS IN RAINY SEASON, 1977 (Vehicles per day)



the rainy season which was based on the results of interviews with drivers, truckers, etc. during the field survey. The ADT of the southern road decreases to 35, whilst the ADT of the northern road increases to 100.

When rainfall is very heavy, traffic is halted at many places crossing the watercourses, particularly between Um Ruaba and Semeih. Vehicles then either must wait until the water runs off, or make long detours in goz areas.

ii. Characteristics of Road Traffic

The characteristics of vehicles and road traffic are summarized as follows:

- a) Medium size trucks with loading capacities of 5 to 8 tons comprise approximately 90% of the total vehicles surveyed in the area. Particularly 6-ton trucks amount to approximately 50% of the total vehicles. The Bedford 6-ton truck is the most popular. Most of the light vehicles are four-wheel drive, and the Fiat 11-ton truck is the most frequently used among heavy trucks. These figures are shown in Annex VI-12.

Table 6-8 in Annex VI-13 shows the distribution of vehicles according to years in service, indicating most of the vehicles are 1 to 4 years old. Average age of medium size trucks is 3.6 years.

- b) As shown in Table 6-9, Annex IV-13, the average loading capacity of van/pick-ups, medium size trucks and heavy trucks is 1.00, 6.10 and 13.10 tons, respectively.
- c) Due to a lack of bus services in the area, passengers and freight are often carried together. As is shown in Table 6-10, Annex VI-13, 77% of all vehicles carry both passengers and freight and empty vehicles total only 2%.
- d) As shown in Table 6-11, Annex VI-13, average payloads are 0.11 tons of freight and 4.71 passengers for vans and pick-ups, 4.14 tons of freight and 9.44 passengers for medium size trucks and 7.19 tons of freight and 6.54 passengers for heavy trucks. Average loading ratios of medium size and heavy trucks are 78% and 70%, respectively.

iii. Vehicular O-D Traffic

Origins and destinations of vehicular traffic are shown in Tables 6-12-1 to 6-12-5, Annex VI-14.

Table VI-2 summarizes the traffic distribution of all types of vehicles (van/pick-up, medium truck, heavy truck and bus) for 8 integrated zones.

The traffic can be divided into those which move

	<u>(vehicles/day)</u>
- within the influence area	81.5
- between the influence area and other areas	81.5
- transiting between other areas	33.4
(through traffic)	

These figures indicate that the traffic which moves within the area is only 41% of the total. Thus, the project road is important in serving the inter-regional traffic as well as the project influence area itself.

Of the total traffic, 28% is traffic generating in El Obeid. Through traffic is 17% of the total. Major zone-pairs and the traffic volumes are as follows:

	<u>(vehicles/day)</u>
El Obeid - Khartoum	40.3
El Obeid - Rahad	22.3
Um Ruaba - Shamagatta	16.5
Nyala - Khartoum	15.6
El Obeid - Um Ruaba	14.9
El Obeid - Kost/Sennar	14.1

TABLE VI-2 DISTRIBUTION OF ROAD TRAFFIC, 1977

(All vehicles)

(Vehicles/day)

D O	Zone No. in Original O-D Table	EL OBEID	UM RUABA	RAHAD	Rest of Project Area	KHAR- TOUM	PORT SUDAN	West SUDAN	Rest of SUDAN	TOTAL
EL OBEID	01	-	14.9	22.3	10.0	40.3	1.3	-	20.0	108.8
UM RUABA	05		-	11.1	23.2	-	-	1.0	9.0	59.2
RAHAD	08			-	0	3.0	0	0.7	3.9	41.0
Rest of Project Area	02, 03, 04, 06, 07, 09, 10				-	1.1	0.3	0	0.9	35.5
KHARTOUM	14					-	-	17.8	6.0	68.2
PORT SUDAN	16						-	0.3	-	1.9
West SUDAN	21, 22, 23, 24							-	0.6	20.4
Rest of SUDAN	11, 12, 13, 15, 17, 18, 19, 20, 25								8.7	57.8
TOTAL										392.8

iv. Commodity Movement on Roads

Movements of commodities are contained in the form of an O-D table in Tables 6-14-1 to 6-14-22 of Annex VI-16, according to the classification of the commodities shown in Annex VI-15. Table VI-3 summarizes the three major movements of commodities by type.

Agricultural products share a high 58% of the total goods traffic, and manufactured foodstuffs, construction materials and manufactured consumer goods follow with 8%, 11% and 9%, respectively.

According to Table VI-4 showing the O-D movements of all types of goods, the traffic between El Obeid and Khartoum is the heaviest in each direction and shares 28% of the total traffic.

v. Passenger Movement on Roads

The characteristics of passenger movements by vehicle on roads are summarized in Table VI-5 which was worked out from the detailed O-D table shown in Annex VI-17.

The passenger traffic can also be divided into the three major movements as follows.

- within the influence area 1,027 (118)* persons/day
- between the influence area and other areas 697 (667)* persons/day
- transiting between the other areas (through traffic) 374 (504)* persons/day

* figures in parenthesis indicate passenger traffic by rail.

TABLE VI-3 COMMODITY MOVEMENT BY ROAD, MAY 1977

		(tons/day)				
Commodity Group	O D	Within Project Area	Between Project Area and Other Area	Transit Between Other Areas	Total	
					Tons	%
10.	Unprocessed Cereals	40.6	56.1	3.8	100.5	13.5
20.	Other Unprocessed Agricultural Foodstuffs	18.1	17.5	22.3	57.9	7.8
30.	Unprocessed Agricultural Cash Crops	41.9 (0.2)	94.1 (2.9)	17.2 (-)	153.2 (3.1)	20.6 (0.4)
31.	Gum Arabic	9.3	29.8	3.3	42.4	5.7
32.	Groundnuts	0.4	0.6	1.6	2.6	0.4
33.	Karkadeh	-	0.4	-	0.4	0.1
34.	Watermelon Seeds	-	9.5	7.9	17.4	2.3
35.	Simsim (sesame)	30.3	20.9	0.6	51.8	7.0
36.	Umbas (Foodstuffs for Animals)	1.7	29.7	3.8	35.2	4.7
37.	Cotton	-	0.3	-	0.3	0.0
40.	Processed Cereal Products	3.3	2.4	0.4	6.1	0.8
50.	Manufactured Foodstuffs	2.6	34.0	19.6	56.2	7.6
60.	Processed Agricultural Cash Crops	40.1	39.5	35.9	115.5	15.5
70.	Livestock and Products	0.7	7.7	4.4	12.8	1.7
80.	Other Manufactured Consumer Goods	4.7	43.9	16.2	64.8	8.7
90.	Forestry Products	10.8	5.3	6.2	22.3	3.0
100.	Mining Products	-	-	-	-	-
110.	Mineral Oil Products	4.0	9.1	4.6	17.7	2.4
120.	Building and Construction Materials	30.3	36.2	13.1	79.6	10.6
130.	Miscellaneous	13.7	17.7	3.0	34.4	4.6
140.	Others	6.4	10.6	5.7	22.7	3.1
Total		217.2	374.1	152.4	743.7	100.0

Note: 1) Figures in parentheses are the tonnage of other unprocessed agricultural cash crops.

TABLE VI-4 COMMODITY MOVEMENT BY ROAD, 1977

(All types of commodities)

(tons/day)

O \ D	Zone No. in Original O-D Table	EL OBEID	UM RUABA	RAHAD	Rest of Project Area	KHARTOUM	PORT SUDAN	West SUDAN	Rest of SUDAN	TOTAL
EL OBEID	01	-	40.8	21.7	5.6	105.7	2.4	-	31.0	207.2
UM RUABA	05	15.0	-	9.1	26.6	-	-	1.2	3.7	55.6
RAHAD	08	36.5	26.5	-	-	2.8	-	-	13.4	79.2
Rest of Project Area	02, 03, 04, 06, 07, 09, 10	13.8	22.8	-	-	2.1	-	-	1.3	40.0
KHARTOUM	14	102.9	-	7.8	2.7	-	-	59.7	10.8	183.9
PORT SUDAN	16	7.8	-	-	1.2	-	-	1.9	-	10.9
West SUDAN	21, 22, 23, 24	-	2.2	4.0	-	36.9	-	-	0.9	44.0
Rest of SUDAN	11, 12, 13, 15, 17, 18, 19, 20, 25	42.0	37.3	1.5	1.5	9.3	-	1.3	32.3	125.2
TOTAL		218.0	129.6	44.1	37.6	156.8	2.4	64.1	93.4	746.0

TABLE VI-5 PASSENGER MOVEMENT BY ROAD, 1977

(persons/day)

O \ D	Zone No. in Original O-D Table	EL OBEID	UM RUABA	RAHAD	Rest of Project Area	KHARTOUM	PORT SUDAN	West SUDAN	Rest of SUDAN	TOTAL
EL OBEID	01		127.7	197.8	89.7	299.4	7.5	-	179.2	901.3
UM RUABA	05			170.7	441.3	-	-	6.0	90.3	836.0
RAHAD	08				0	36.9	0	6.1	47.7	459.2
Rest of Project Area	02, 03, 04, 06, 07, 09, 10					18.8	1.2	0	4.2	555.2
KHARTOUM	14						-	142.1	99.0	596.2
PORT SUDAN	16							0.6	-	9.3
West SUDAN	21, 22, 23, 24								4.0	158.8
Rest of SUDAN	11, 12, 13, 15, 17, 18, 19, 20, 25								127.8	680.0
TOTAL										4,196.0

Although the general features of a modal-split are seen in that longer trips are made by rail, quite a large number of passengers still have to travel by uncomfortable truck, even for long distances. This is due to the fact that trains are over crowded and bus service is inadequate.

6.03.3 Railway Traffic

i. Movement of Commodities by Rail

The historical trend of tonnage of commodities carried by rail has stayed at the same level generally during the last seven years as shown in Table VI-6 and FIG. VI-5. The tonnage handled at the four stations-El Obeid, Rahad, Semeih and Um Ruaba, has recovered by 30 percent between 1974/75 and 1976/77.

At the above four stations received tonnage comprises 60% and forwarded tonnage 40% of the total movement in the period 1976/77. Nearly 80% of the total tonnage is handled at El Obeid station.

Table VI-7 shows the major forwarded and received commodities. Of the total transported tonnage, 80% is made up of cash crops, oil cake, sugar, salt, petroleum products and grains. Groundnuts are the largest single commodity exported out of the area, while fuel is the largest item imported into the area.

TABLE VI-6 RAILWAY FREIGHT HANDLED AT THE FOUR STATIONS 1)

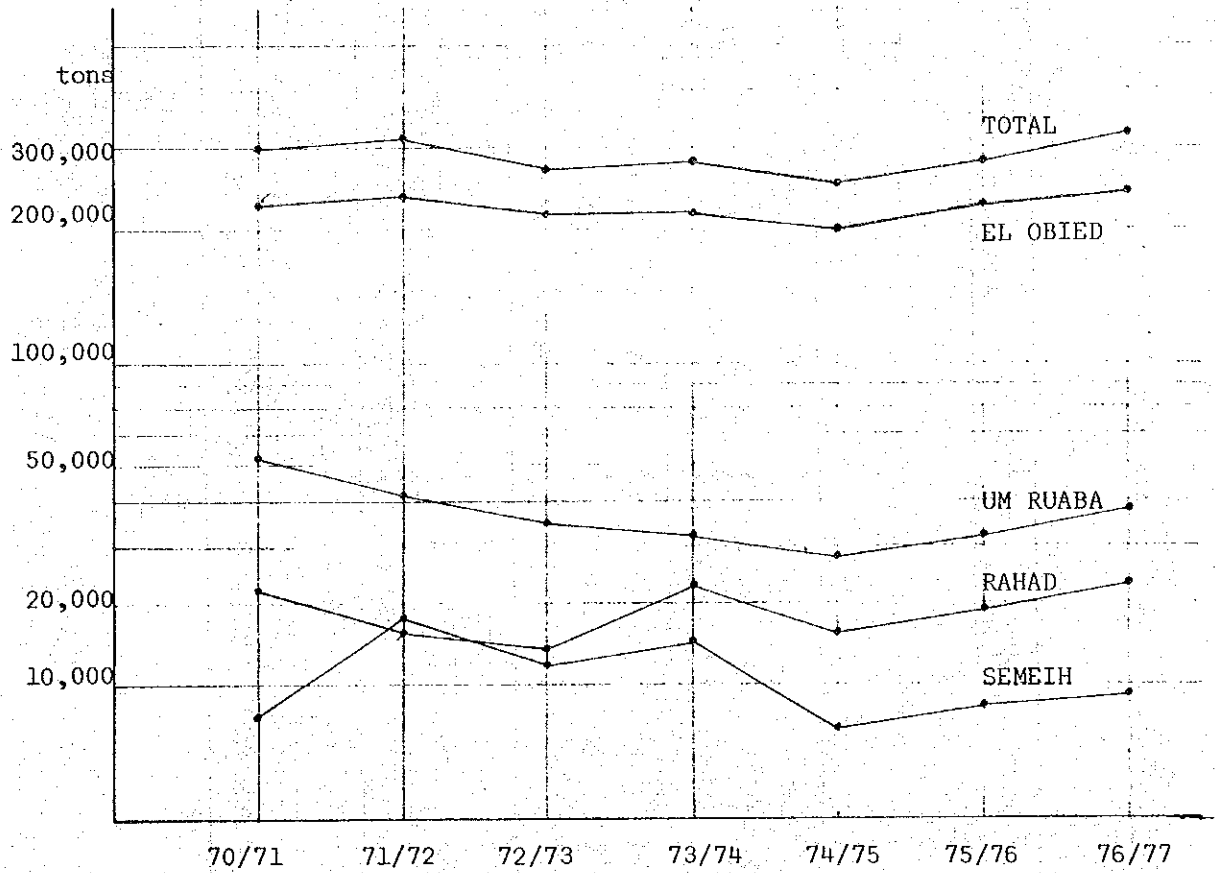
(tons/year)

Station	Year	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77
EL OBEID	Forwarded	76,575	77,207	94,089	68,673	91,308	66,859	76,226
	Received	139,171	148,973	110,056	135,104	98,040	147,283	167,917
	Total	215,746	226,180	204,145	203,777	189,348	214,142	244,143
RAHAD	Forwarded	13,132	9,576	6,701	13,534	7,392	11,598	13,223
	Received	8,329	6,602	6,708	9,784	8,568	7,906	9,014
	Total	21,461	16,178	13,409	23,318	15,960	19,504	22,237
SEMEIH	Forwarded	4,858	15,886	11,792	13,415	3,552	5,487	6,256
	Received	2,285	2,491	785	1,492	2,232	2,094	2,387
	Total	7,143	18,377	12,577	14,907	5,784	7,581	8,643
UM RUABA	Forwarded	31,056	20,099	20,613	17,059	16,596	22,621	25,790
	Received	21,276	21,097	14,328	14,574	11,480	8,877	10,121
	Total	52,332	41,196	34,941	31,633	28,076	31,498	35,911
TOTAL	Forwarded	125,621	122,768	133,195	112,681	118,848	106,565	121,495
	Received	171,061	179,163	131,877	160,954	120,320	166,160	189,439
	Total	296,682	301,931	265,072	273,635	239,168	272,725	310,934

Source: Sudan Railways Corporation, 1977

Note: 1) Tonnage excludes parcels and livestock.

FIG. VI-5 RAILWAY FREIGHT HANDLED AT THE FOUR STATIONS



Source: Produced from Table VI-6.

TABLE VI-7 ESTIMATE OF RAILWAY FREIGHT HANDLED AT THE FOUR STATIONS BY TYPE OF GOODS (1976/77)

Item	EL OBEID			RAHAD			SEMEIH			UM RUABA			TOTAL		
	For-warded	Receiv-ed	Total	For-warded	Receiv-ed	Total	For-warded	Receiv-ed	Total	For-warded	Receiv-ed	Total	For-warded	Receiv-ed	Total
10. Wheat, Dura	43	6,945	6,988	-	84	84	-	-	-	-	387	387	43	7,416	7,459
30. Crops	57,772	-	57,772	10,181	-	10,181	6,193	-	6,193	11,658	-	11,658	85,804	-	85,804
31. Gum Arabic	6,325	-	6,325	446	-	446	-	-	-	300	-	300	7,071	-	7,071
32. Groundnuts	45,088	-	45,088	6,046	-	6,046	-	-	-	8,006	-	8,006	59,140	-	59,140
33. Karkadeh	422	-	422	246	-	246	-	-	-	1,093	-	1,093	1,761	-	1,761
34. Watermelon Seeds	3,855	-	3,855	11	-	11	-	-	-	42	-	42	3,908	-	3,908
35. Sesame	2,082	-	2,082	3,425	-	3,425	-	-	-	2,217	-	2,217	7,724	-	7,724
36. -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37. Cotton/Cottonseeds	-	-	-	7	-	7	6,193	-	6,193	-	-	-	6,200	-	6,200
40. Flour	-	18,088	18,088	-	1,666	1,666	-	-	-	-	-	-	-	21,774	21,774
60. Oil Cakes Sugar/Salt	14,600	63,703	78,303	2,778	3,703	6,481	-	338	338	12,842	-	12,842	30,220	70,212	100,432
70. Livestock ¹⁾	(32,398)	(1,237)	(33,635)	(-)	(55)	(55)	(-)	(-)	(-)	(4,159)	(-)	(4,159)	(36,557)	(1,292)	(37,794)
110. Petroleum Products	-	28,751	28,751	-	2,559	2,559	-	1,863	1,863	-	-	-	-	36,732	36,732
120. Cement	-	8,451	8,451	-	101	101	-	67	67	-	-	-	-	8,788	8,788
Others	3,811	41,979	45,790	264	901	1,165	63	119	182	1,290	-	1,290	5,428	44,517	49,945
Total	76,226	167,917	244,143	13,223	9,014	22,237	6,256	2,387	8,643	25,790	10,121	35,911	121,495	189,439	310,934

Source: Sudan Railways Corporation, 1977

Note: 1) Figures in parentheses indicate number of Livestock.

ii. Passenger Movement by Railways

Table VI-8 and FIG. VI-6 show a declining tendency of railway passenger volume between 1970/71 and 1974/75. After 1974/75, however, passenger traffic began to increase. It was observed during the survey that all the trains were fully occupied, and some passengers were even riding on the roofs of the coaches.

Table VI-9 shows the distribution pattern of railway passengers whose trip length is much longer than that of road passengers. Details of the estimate are presented in Annex VI-20. According to Table 6-18-2 in Annex VI-20, major O-D zone pair and traffic volume of railway passengers are as follows.

	(persons/day)
El Obeid - Khartoum	303.9
Khartoum - Nyala	246.9
El Obeid - Kosti/Sennar	108.1
Wad Medani - Nyala	75.4
Rahad - Khartoum	72.4
El Obeid - Um Ruaba	59.6

There is a tendency for passengers to choose higher class coaches when travelling, as shown in Table VI-10.

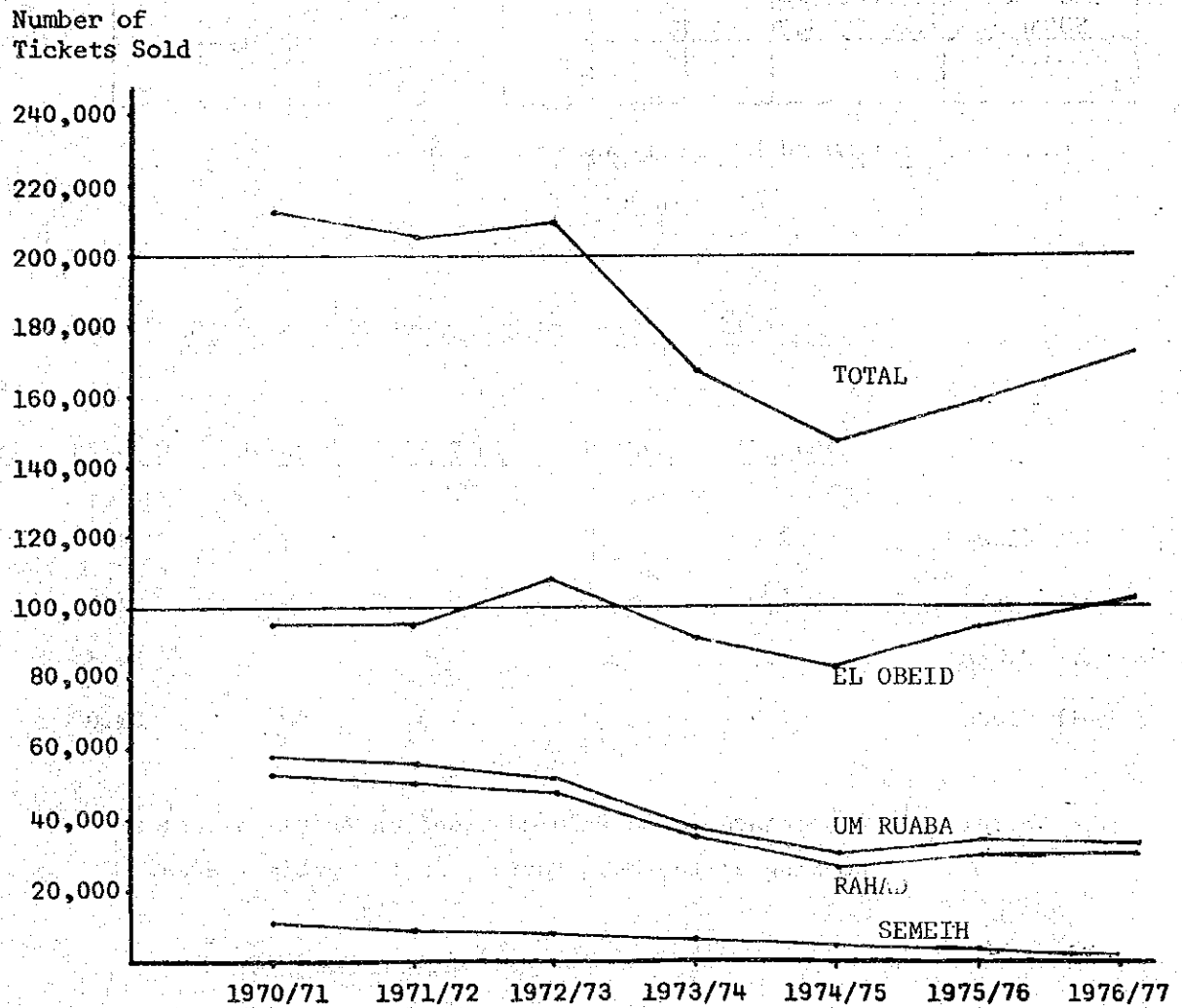
TABLE VI-8 PASSENGER TICKETS SOLD AT THE FOUR STATIONS

Station \ Year	(tickets)						
	1970/71	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77 ¹⁾
EL OBEID	94,959	95,142	109,248	90,345	84,309	92,474	100,466
RAHAD	51,298	48,130	44,807	35,703	28,343	31,224	33,922
SEMEIH	10,199	7,765	7,507	5,412	4,028	3,168	3,442
UM RUABA	56,266	53,831	48,137	36,844	30,770	33,327	36,207
TOTAL	212,722	204,868	209,699	168,304	147,450	160,193	174,037

Source: Sudan Railway Corporation, 1977

Note: 1) Estimated by the number of passengers on all the railways in 1975/76 and in 1976/77.

FIG. VI-6 PASSENGER TICKETS SOLD AT THE FOUR STATIONS



Source: Produced from Table VI-8.

TABLE VI-9 PASSENGER MOVEMENT BY RAIL, 1977

(persons/day)

O \ D	Zone No. in Original O-D Table	EL OBEID	Um RUABA	RAHAD	Rest of Project Area	KHARTOUM	PORT SUDAN	West SUDAN	Rest of SUDAN	TOTAL
EL OBEID	01		59.6	3.4	1.5	303.9	5.2	1.9	176.6	552.1
UM RUABA	05			51.1	1.9	-	-	13.2	-	125.8
RAHAD	08				0	72.4	0.7	-	70.1	197.7
Rest of Project Area	02,03,04,06,07,09,10					2.3	2.6	0	16.8	25.1
KHARTOUM	14						-	279.4	4.0	662.0
PORT SUDAN	16							3.6	0.7	12.8
West SUDAN	21,22,23,24								215.0	513.1
Rest of SUDAN	11,12,13,15,17,18,19,20,25								0.8	484.8
TOTAL										2,573.4

Source: Estimated by the study team, 1977.

TABLE VI-10 PASSENGER TICKETS SOLD BY CLASS ¹⁾

(%)

	<u>1970/71</u>	<u>1971/72</u>	<u>1972/73</u>	<u>1973/74</u>	<u>1974/75</u>	<u>1975/76</u>
1st Class	2.3	2.2	2.75	3.4	4.7	4.6
2nd Class	5.9	5.2	5.75	6.7	7.8	7.4
3rd Class	23.9	20.8	23.6	27.8	34.5	30.9
4th Class	67.9	71.8	67.9	62.1	53.0	57.1

Note: 1) Percentage is calculated based on total passenger booking at the four stations in the project area.

6.04 Transportation Cost

6.04.1 Vehicle Operating Cost

i. Field Survey on Vehicle Operating Cost

In order to estimate vehicle operating cost under various conditions for both existing and proposed roads, the following surveys were carried out during the field survey. The surveys consist mainly of,

- a) interviews with dealers and operators of garages and trucking companies,
- b) interviews with drivers carried out during the O-D survey in the area,
- c) analyses of the results derived from similar surveys, and
- d) driving survey using four-wheel drive pick-up.

Considering the particular conditions of the roads in the area, the following surface types were chosen for the analysis.

- a) paved
- b) gravel
- c) hard surface clay
- d) loose sand

Regarding c) and d) above, the differences of vehicle operating costs in the rainy season and in the dry season were also studied.

ii. Characteristics of the Representative Vehicles

On the basis of the results of interviews with dealers and those of the traffic survey conducted in the area, the representative vehicles mainly being used at present and expected to be used in the future were selected as follows.

- a) Car Toyota Corolla 1200
- b) Van/pick-up Toyota Pick-up (4 wheel drive)
- c) Medium truck Bedford 6-ton
- d) Heavy truck Fiat 682 11-ton
- e) Bus Bedford 6-ton (remodeled)

Cars are included in view of the forecast that they are expected to be used extensively after the improvement of the road. However, at present, cars are restricted almost exclusively to urban areas. Table VI-11 shows the characteristics of the representative vehicles.

TABLE VI-11 CHARACTERISTICS OF REPRESENTATIVE VEHICLES

	<u>Car</u>	<u>Van, Pick-up</u>	<u>Medium Truck</u>	<u>Heavy Truck</u>	<u>Bus</u>
Representative Vehicle	Toyota Corolla	Toyota Pick-up	Bedford	Fiat 682	Bedford
Loading Capacity	4 pass.	10 pass. 1.5 tons	6 tons	11 tons	44 pass.
Number of Axles	2	2	2	2	2
Number of Tyres	4	4	4	6	4
Fuel Used 1)	Benzine (Gasoline)	Benzine (Gasoline)	Gasoline (Diesel)	Gasoline (Diesel)	Gasoline (Diesel)
Maximum Cruising Speed (km/h)	125	110	90	90	90
Average Life (Years)	10	8	6	6	5

Source: Interviews with dealers

Note: 1) In the Sudan "Benzine" is the common term for gasoline and "Gasoline" is used to designate diesel fuel.

iii. Estimates of Vehicle Operating Cost

Vehicle operating cost of each representative vehicle was estimated based on an analysis of such factors as:

- depreciation and interest of vehicle
- insurance
- wages of drivers and assistants
- licensing fees
- fuel consumption
- engine oil consumption
- tyre wear
- maintenance
- overhead

Both economic and financial operating costs of vehicles were at first estimated for the four different surface types mentioned previously for flat roads in the dry season. 1977 prices were used in the analysis.

In adjusting the vehicle operating costs due to changes in road gradient, the percentage change of fuel consumption was studied as described in Table 6-20-19 of Annex VI-21. Changes in surface conditions during the rainy season were also taken into consideration. Vehicle operating costs in the dry season were adjusted and increased according to information obtained by interviews conducted in the area. Tables VI-12 to VI-16 show the results of the analysis, as described in detail in Annex VI-21.

6.04.2 Railway Operating Cost

Railway operating cost is described in 9.03, Chapter IX, within the scope of the study in estimating the diverted traffic and the benefits.

TABLE VI-12 OPERATING COST OF VEHICLES, CAR

1)
(mm/km)

Dry Season

Surface Cost Item	Financial Cost				Economic Cost				
	Paved	Gravel	Hard Surface	Loose Sand	Paved	Gravel	Hard Surface	Loose Sand	
Depreciation and Interest	28.90	36.13	48.17	-	14.12	17.75	23.67	-	
Insurance Fees	7.37	9.22	12.29	-	6.27	7.83	10.45	-	
Wages	-	-	-	-	-	-	-	-	
License Fees	0.55	0.69	0.92	-	-	-	-	-	
Fuel Consumption	8.10	10.12	12.14	-	4.22	5.28	6.34	-	
Engine Oil Consumption	0.57	0.67	0.83	-	0.49	0.58	0.72	-	
Tyre Wear	2.33	4.67	7.78	-	1.67	3.33	5.56	-	
Maintenance	Parts	4.62	5.68	15.98	-	2.27	2.79	7.85	-
	Labor	0.30	0.40	0.80	-	0.30	0.40	0.80	-
Overhead	-	-	-	-	-	-	-	-	
Total Cost on Flat (0-3%) Road	52.74	67.58	98.91	-	29.34	37.96	55.39	-	
Savings 2)	-	14.84	45.84	-	-	8.62	26.05	-	
	-	-	31.33	-	-	-	17.43	-	
Total Cost on 3-5% Road					29.76	38.49	56.02	-	
Savings 2)					-	8.73	26.26	-	
					-	-	17.53	-	

Rainy Season

Total Cost on Flat (0-3%) Road					29.34	37.96	83.09	-
Savings 2)					-	8.62	53.75	-
					-	-	45.13	-
Total Cost on 3-5% Road					29.76	38.49	84.03	-
Savings 2)					-	8.73	54.27	-
					-	-	45.54	-

Notes: 1) mm is equal to 1/10 of a piasta or 1/1000 of a Sudanese pound.

2) The upper line shows a balance against the paved road and the lower line shows a balance against the gravel road.

TABLE VI-13 OPERATING COST OF VEHICLES, VAN/PICK-UP

Dry Season 1)
(mm/km)

Surface Cost Item	Financial Cost				Economic Cost				
	Paved	Gravel	Hard Surface	Loose Sand	Paved	Gravel	Hard Surface	Loose Sand	
Depreciation and Interest	27.07	30.76	37.60	45.12	17.71	20.12	24.59	29.51	
Insurance Fees	5.93	6.74	8.24	9.88	5.04	5.73	7.00	8.40	
Wages	-	-	-	-	-	-	-	-	
License Fees	0.38	0.44	0.53	0.64	-	-	-	-	
Fuel Consumption	20.24	25.30	30.36	45.53	10.56	13.20	15.84	23.76	
Engine Oil Consumption	0.72	0.83	0.98	1.29	0.63	0.72	0.85	1.12	
Tyre Wear	5.71	11.11	20.00	16.67	4.00	7.78	14.00	11.67	
Maintenance	Parts	6.32	9.03	22.57	35.21	4.13	5.90	14.76	23.03
	Labor	0.36	0.52	1.04	1.44	0.36	0.52	1.04	1.44
Overhead	-	-	-	-	-	-	-	-	
Total Cost on Flat (0-3%) Road	66.73	84.73	121.32	155.78	42.43	53.97	78.08	98.93	
Savings 2)	-	18.00	54.59	89.05	-	11.54	35.65	56.50	
	-	-	36.59	71.05	-	-	24.11	44.96	
Total Cost on 3-5% Road					44.96	57.14	81.88	104.63	
Savings 2)					-	12.18	36.92	59.67	
					-	-	24.74	-	

Rainy Season

Total Cost on Flat (0-3%) Road					42.43	53.97	117.12	98.93
Savings 2)					-	11.54	74.69	56.50
					-	-	63.15	44.96
Total Cost on 3-5% Road					44.96	57.14	122.82	104.63
Savings 2)					-	12.18	77.86	59.67
					-	-	65.68	47.49

Notes: 1) mm is equal to 1/10 of a piasta or 1/1000 of a Sudanese pound.

2) The upper line shows a balance against the paved road and the lower line shows a balance against the gravel road.

TABLE VI-14 OPERATING COST OF VEHICLES, MEDIUM TRUCK

1)
(mm/km)

Dry Season

Surface Cost Item	Financial Cost				Economic Cost			
	Paved	Gravel	Hard Surface	Loose Sand	Paved	Gravel	Hard Surface	Loose Sand
Depreciation and Interest	16.91	19.73	22.91	35.51	12.88	15.02	17.44	27.04
Insurance Fees	2.74	3.20	3.72	5.76	2.33	2.72	3.16	4.90
Wages	17.14	20.00	23.23	36.00	16.74	19.53	22.68	35.16
License Fees	0.40	0.47	0.54	0.84	-	-	-	-
Fuel Consumption	20.24	24.29	30.36	48.57	17.16	20.59	25.74	41.18
Engine Oil Consumption	0.94	1.06	1.26	1.63	0.82	0.92	1.10	1.42
Tyre Wear	11.88	23.25	44.57	38.20	7.87	15.41	29.53	25.31
Maintenance								
Parts	6.70	9.80	25.78	40.21	5.10	7.46	19.63	30.62
Labor	1.20	1.96	3.92	5.48	1.20	1.96	3.92	5.48
Overhead	7.82	10.38	15.63	21.22	7.82	10.38	15.63	21.22
Total Cost on Flat (0-3%) Road	85.97	114.14	171.92	233.42	71.92	93.99	138.83	102.33
Savings 2)	-	28.17	85.95	147.45	-	22.07	66.91	120.41
	-	-	57.78	119.28	-	-	44.84	98.34
Total Cost on 3-5% Road					79.30	102.84	149.90	210.04
Savings 2)					-	23.54	70.60	134.74
					-	-	47.06	107.20

Rainy Season

Total Cost on Flat (0-3%) Road					71.92	93.99	208.25	192.33
Savings 2)					-	22.07	136.33	120.41
					-	-	114.26	98.34
Total Cost on 3-5% Road					79.30	102.84	224.85	210.04
Savings 2)					-	23.54	145.55	130.74
					-	-	122.01	107.20

Notes: 1) mm is equal to 1/10 of a piasta or 1/1000 of a Sudanese pound.

2) The upper line shows a balance against the paved road and the lower line shows a balance against the gravel road.

TABLE VI-15 OPERATING COST OF VEHICLES, HEAVY TRUCK

1)

Dry Season

(mm/km)

Surface Cost Item	Financial Cost				Economic Cost				
	Paved	Gravel	Hard Surface	Loose Sand	Paved	Gravel	Hard Surface	Loose Sand	
Depreciation and Interest	38.93	46.11	53.09	83.43	25.96	30.74	35.39	55.62	
Insurance Fees	7.69	9.11	10.49	16.48	6.54	7.74	8.91	14.01	
Wages	16.00	18.95	21.82	34.29	15.63	18.51	21.31	33.49	
License Fees	0.48	0.57	0.65	1.03	-	-	-	-	
Fuel Consumption	24.29	31.57	38.86	72.86	20.59	26.77	32.94	61.77	
Engine Oil Consumption	2.77	3.18	3.84	4.98	2.41	2.77	3.34	4.33	
Tyre Wear	23.56	46.10	88.35	75.73	16.49	32.26	61.84	53.00	
Maintenance	Parts	15.26	22.89	59.77	92.84	10.17	15.26	39.85	61.89
	Labor	1.40	2.28	4.56	6.40	1.40	2.28	4.56	6.40
Overhead	13.04	18.08	28.14	38.80	13.04	18.08	28.14	38.80	
Total Cost on Flat (0-3%) Road	143.42	198.84	309.57	426.84	112.23	154.41	236.28	329.31	
Savings 2)	-	55.42	166.15	283.42	-	42.18	124.05	217.08	
	-	-	110.73	228.00	-	-	81.87	174.90	
Total Cost on 3-5% Road					121.08	165.92	250.44	355.87	
Savings 2)					-	44.84	129.36	234.79	
					-	-	84.52	189.95	

Rainy Season

Total Cost on Flat (0-3%) Road					112.23	154.41	354.42	329.31
Savings 2)					-	42.18	242.19	217.08
					-	-	200.01	179.90
Total Cost on 3-5% Road					121.08	165.92	375.66	355.87
Savings 2)					-	44.84	254.58	234.79
					-	-	209.74	189.95

Notes: 1) mm is equal to 1/10 of a piasta or 1/1000 of a Sudanese pound.

2) The upper line shows a balance against the paved road and the lower line shows a balance against the gravel road.

TABLE VI-16 OPERATING COST OF VEHICLES, BUS

1)

(mm/km)

Dry Season

Surface Cost Item	Financial Cost				Economic Cost				
	Paved	Gravel	Hard Surface	Loose Sand	Paved	Gravel	Hard Surface	Loose Sand	
Depreciation and Interest	18.39	21.45	24.91	38.62	13.93	16.25	18.88	29.26	
Insurance Fees	2.64	3.08	3.58	5.55	2.25	2.62	3.04	4.72	
Wages	15.00	17.50	20.32	31.50	14.60	17.03	19.77	30.65	
License Fees	0.33	0.39	0.45	0.70	-	-	-	-	
Fuel Consumption	20.24	24.29	30.36	48.57	17.16	20.59	25.74	41.18	
Engine Oil Consumption	0.94	1.06	1.26	1.63	0.82	0.92	1.10	1.42	
Tyre Wear	11.88	23.25	44.57	38.20	7.87	15.41	29.53	25.31	
Maintenance	Parts	7.61	11.13	29.28	45.67	5.77	8.43	22.18	34.60
	Labor	1.20	1.96	3.92	5.48	1.20	1.96	3.92	5.48
Overhead	7.82	10.41	15.87	21.59	7.82	10.41	15.87	21.59	
Total Cost on Flat (0-3%) Road	86.05	114.52	174.52	237.51	71.42	93.62	140.03	194.21	
Savings 2)	-	28.47	88.47	151.46	-	22.20	68.61	122.79	
	-	-	60.00	122.99	-	-	46.41	100.59	
Total Cost on 3-5% Road					78.80	102.47	151.10	211.92	
Savings 2)					-	23.67	72.30	133.12	
					-	-	48.63	109.45	

Rainy Season

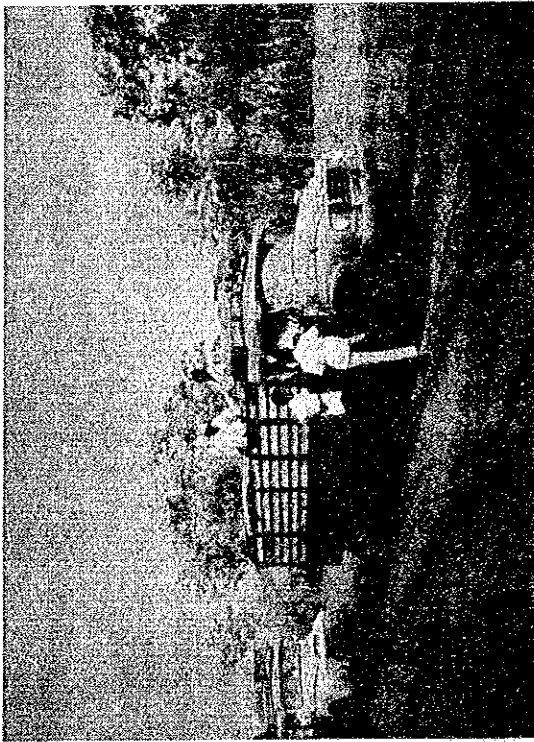
Total Cost on Flat (0-3%) Road					71.42	93.62	210.05	194.21
Savings 2)					-	22.20	138.63	122.21
					-	-	116.43	100.59
Total Cost on 3-5% Road					78.80	102.47	226.65	211.92
Savings 2)					-	23.67	147.85	133.12
					-	-	124.18	109.45

Notes: 1) mm is equal to 1/10 of a piasta or 1/1000 of a Sudanese pound.

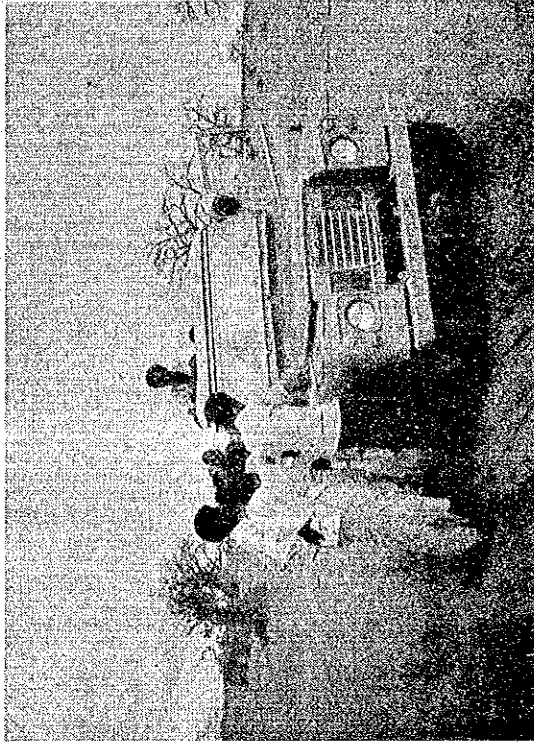
2) The upper line shows a balance against the paved road and the lower line shows a balance against the gravel road.

Vehicles on the existing roads

At Um Ruaba



At El Obeid



At El Obeid

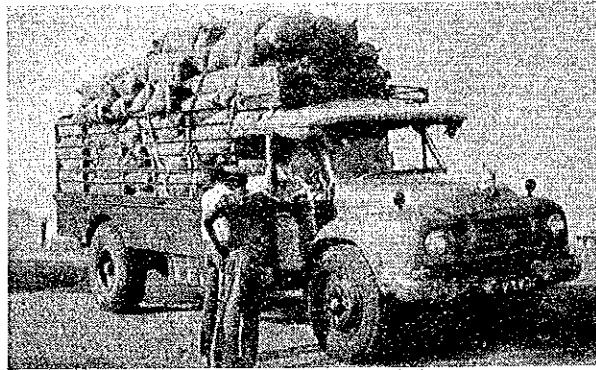


Representative Vehicles (on the road of khartoum-Wad Medani)

Heavy Truck



Medium Truck



Bus



Pick-up



CHAPTER VII

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7.00 ALTERNATIVE ROUTES; ENGINEERING AND COST

As already mentioned in CHAPTER I, Introduction, the objective of the first stage of the study is to find the most suitable route by comparing several alternative plans for connecting El Obeid and Um Ruaba. The photo mosaic of a scale of 1 : 50,000 and other data developed by the field studies are utilized in this study. The individual plan of each alternative is explained in the following paragraphs of 7.01, on the next page.

Estimated normal traffic volume in 1983, the opening year of the project, is approximately 180 vehicles per day and in the last year of the project life, 2002, is approximately 580 per day. These estimates vary little among the alternatives. These estimates are presented in detail in CHAPTER IX.

In addition, the topography of these routes consists mainly of flat land or gently sloping hills. Therefore, in the comparison of alternative plans for determining the optimum route, the estimation of work quantities for each plan is based on the same standards and specifications. The economic cost of construction and maintenance for each plan is estimated and forwarded to 10.01, CHAPTER X, Benefit and Cost Analysis, for evaluation in determining the optimum route.

Upon determination of the optimum route, further studies on bypasses, drainage structures, and pavement designs, as well as the refinement of the cost estimate on this route, will be carried out in the second stage of this study, (Ref. next Chapter.)

7.01 Proposed Alternative Routes

7.01.1 Southern Corridor

i. Routes between El Obeid and Rahad

a) Route A (68 km)

This route runs along the east side of the railway and connects El Obeid and Rahad, passing through the mountains of J. Kordofan and J. El Ain.

b) Route B (73 km)

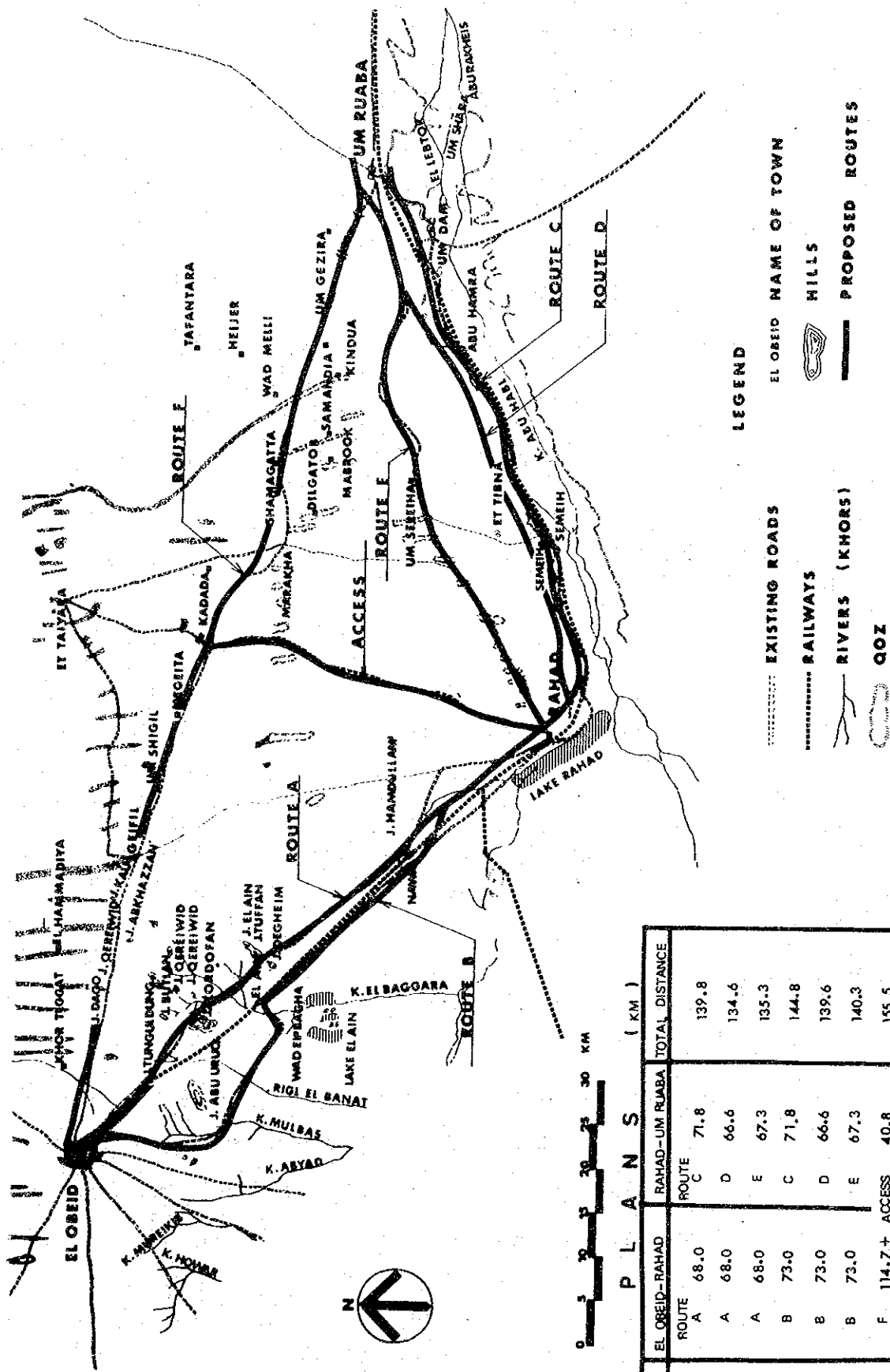
This route runs along the west side of the railway and connects El Obeid and Rahad, passing near the reservoir of El Ain.

ii. Routes between Rahad and Um Ruaba

a) Route C (72 km)

This route runs along the existing track, which is used in the dry season, passing through cotton clay over the flood plain of K. Abu Habl.

FIG. VI. 1 ALTERNATIVE PLANS



P L A N S (K M)

PLAN	EL OBEID-RAHAD ROUTE	RAHAD-UM RUABA ROUTE	TOTAL DISTANCE
1	A 68.0	C 71.8	139.8
2	A 68.0	D 66.6	134.6
3	A 68.0	E 67.3	135.3
4	B 73.0	C 71.8	144.8
5	B 73.0	D 66.6	139.6
6	B 73.0	E 67.3	140.3
7	F 114.7 + ACCESS	40.8	155.5

b) Route D (67 km)

This route runs into the hilly terrain at the northern side of the railways making a short detour from the flood plain of K. Abu Habl.

c) Route E (67 km)

This route runs along the existing track which is used during the rainy season in the northern hilly sand dune terrain.

7.01.2 Northern Corridor

i. Northern Route

a) Route F (115 km and access road 41 km)

This route directly connects El Obeid and Um Ruaba and the access road is planned to connect Rahad to this route.

7.01.3 Seven Alternative Plans

Seven alternative plans, which are the combinations of Routes A, B, C, D, E and F listed in the following table, are the objects of the first stage of this study. They are indicated in FIG. VII-1 and Tables VII-1 and VII-2.