AFRICAN DEVELOPMENT BANK

THE DEMOCRATIC REPUBLIC OF THE SUDAN
MINISTRY OF TRANSPORT
ROADS AND BRIDGES PUBLIC CORPORATION

FEASIBILITY AND PRELIMINARY ENGINEERING STUDY OF ROAD PROJECT EL OBEID-UM RUABA

FINAL REPORT
ANNEXES

MARCH 1978

JAPAN INTERNATIONAL COOPERATION AGENCY

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TABLE 3-1 TOTAL POPULATION IN THE SUDAN

Year	Population		Percentage	Rate of Annual Increase[1]	
	Total (A)	Urban (B)	of (B)/(A)	Total (D)	Urban (E)
	('000)	('000)	(%)	(%)	(%)
1966	14,120	1,492	10.6		
1967	15,504	1,574	10.2	5.8	5.5
1968	14,936	1,661	11.1		5.5
1969	15,312	1,752	11.4		
1970	15,695	1,848	11.8	2.5	5.5
1971	16,087	1,950	12.1	2.5	5.5
1972	16,489	2,058	12.5	2.5	5.5
1973	16,901	2,170	12.8	2.5	5.4
1974	17,324	2,289	13.2	2.5	5.5
AVERAGE			11.7[2]	2.6[3]	5.5[3]

Figures in A and B indicate estimates of questionable reliability.

Source: Dept. of Economics and Social Affairs, Statistical Office, Demographic Year Book 27th Issue, 1976, U.N. New York, N.Y., U.S.A.

Notes:
1) Rates of annual increase are calculated from the figures in Columns A and B.
2) Indicating the average of percentage figures in Column C.
3) Indicating the average annual growth rate from 1966 to 1974.

TABLE 3-2 POPULATION AND DENSITY BY PROVINCE IN 1955/56 AND 1973

Province	Area km^2 (A)	Population ('000) 1955/56 (B)	Population ('000) 1973 (C)	Density (persons/km^2) 1955/56 (D)=B/A	Density (persons/km^2) 1973 (E)=C/A	Average Growth Rate (I) (%) p.a. 1956-'73 (F) 1)	Revised Population ('000) 1973 (G) 2)	Average Growth Rate (II) (%) p.a. 1956-'73 (H) 3)
Bahrel Ghazal	213,751	999	1,367	5	6	1.9	1,446	2.2
Blue Nile	142,138	2,069	3,914	15	28	3.8	4,065	4.1
Darfur	496,369	1,329	1,839	3	4	1.9	1,945	2.3
Equatoria	198,121	904	725	5	4	-1.3	766	-1.0
Kassala and Red Sea	340,655	941	1,472	3	5	2.6	1,557	3.0
Kordofan	380,546	1,762	2,010	5	5	0.8	2,202	1.3
Northern	477,074	873	902	2	2	0.2	954	0.5
Upper Nile	236,180	889	799	4	3	-0.7	845	0.3
Khartoum	20,961	505	1,113	24	53	4.8	1,178	5.1
Total	2,505,805	10,263	14,141	4	6	1.9	14,958	2.2

Source: Department of Statistics, Statistical Year Book, 1973

Notes: 1) Average growth rate (I) p.a. is estimated by Column (B) and (C).

2) The total population is given by Dept. of Statistics, National Income 1972/73-1974/75. Revised population in province is estimated by adjusting provincial populations in Column (C) to the total of 14,958,000.

3) The rates are estimated by using the revised population in Column (B) and (G).

ANNEX III-3

TABLE 3-3 LABOUR FORCE BY OCCUPATION

Occupation	Percentage
Professional and Technical	1.9
Administrative and Managerial	0.4
Clerical and Related Scales	1.4
Salesmen	4.5
Services Workers	7.6
Agricultural, Animal and Forestry	71.6
Production, Transport, Operation	12.6
TOTAL	100.0

Source: Population Census 1973 (Ministry of Planning, Economic Survey, 1975/76)

Note: These figures are provisional and subject to revision.

ANNEX III-4

TABLE 3-4 COTTON PRODUCTION BY VARIETY

Variety	1973/74		1974/75		1975/76 1)		
	Acreage	Production in bales	Acreage	Production in bales	Acreage	Production in bales	
						Min.	Max.
Long Staple	824,500	1,009,000	838,000	790,500	593,523	355,695	449,111
Medium	196,500	210,400	231,000	240,000	227,839	142,260	172,642
Short	157,000	18,400	99,000	27,000	132,235	26,730	40,270
Experiments	-	-	-	-	3,932	4,398	4,894
Total	1,178,000	1,237,800	1,168,000	1,057,500	957,529	529,084	666,917

Source: Cotton Public Corporation (Economic Survey, 1975/76)

Note: 1) Output of 1975/76 is an estimate.

ANNEX III-5

TABLE 3-5 AREA, PRODUCTION AND AVERAGE YIELD FOR SOME AGRICULTUREAL CROPS 1973/74 - 1975/76

	1973/1974			1974/1975			1975/1976[1]		
	Area Fed.	Production Ton	Average Yield kg/Fed.	Area Fed.	Production Ton	Average Yield kg/Fed.	Area Fed.	Estimated Production Ton	Average Yield kg/Fed.
Dura	5,301,200	1,628,290	309	5,577,030	1,704,853	303	6,200,309	2,055,280	331
Dukhn	2,705,870	281,531	104	2,576,380	400,540	156	2,512,160	403,145	161
Groundnuts	1,725,303	543,801	315	1,785,290	929,910	521	2,065,740	930,765	451
Sesame	2,192,560	237,845	109	2,172,690	233,400	107	2,291,045	238,080	104
Wheat	420,072	236,067	562	591,437	276,265	467	713,790	397,030	556
Cotton	1,178,000	-	-	1,168,000	-	-	957,000	-	-
Total	13,523,000	-	-	13,870,000	-	-	13,783,000	-	-

Source: Ministry of Agriculture, Food and Natural Resources (Economic Survey, 1975/76)

Note: 1) Estimated.

ANNEX III-6

TABLE 3-6 GUM ARABIC PRODUCTION 1970/71 - 1975/76

(Ton)

1970/71	1971/72	1972/73	1973/74	1974/75	1975/76
44,355	25,949	21,194	22,000	52,000	30,000

Source: Forests Department, Ministry of Agriculture, Food and Natural Resources (Economic Survey, 1975/76)

Note: 1) Estimated.

ANNEX III-7

TABLE 3-7 DOMESTIC PRODUCTION OF SUGAR AND THE RATIOS OF PRODUCTION TO LOCAL CONSUMPTION FOR THE SEASONS, 1972/73 - 1975/76

Season	Domestic Production (Ton)	Consumption (Ton)	Ratio of Production to Consumption (%)
1972/73	112,641	250,000	45
1973/74	120,571	269,754	45
1974/75	128,651	257,917	50
1975/76	124,000 (Estimated)	310,000	40

Source: Sugar and Beverages Corporation (Economic Survey, 1975/76)

ANNEX III-8

TABLE 3-8 LIVESTOCK WEALTH ESTIMATES FOR THE FISCAL YEAR 1973/74

(Heads)

Province	Cattle	Sheep	Goats	Camels
Kordofan	1,989,850	2,961,330	1,004,850	1,231,300
Khartoum	57,980	91,480	346,140	54,060
Darfur	4,752,420	2,900,860	2,507,870	434,350
Blue Nile	1,196,470	3,623,970	2,403,320	252,140
Kassala	385,590	1,116,210	655,630	637,710
Northern	207,350	525,810	327,890	79,840
Upper Nile	1,850,820	697,810	1,242,650	-
Equatoria	628,610	478,420	861,300	-
Bahr El Ghazal	3,084,680	976,820	1,146,960	-
Total	14,153,770	13,272,710	10,496,610	2,698,400

Source: Ministry of Agriculture, Food and Natural Resources (Economic Survey, 1975/76)

TABLE 3-9 GROSS DOMESTIC PRODUCT ACCORDING TO THE CURRENT PRICES IN LS MILLION

(LS Million and Percentage)

	1966/67		1967/68		1968/69		1969/70		1970/71		1971/72		1972/73		1973/74		1974/75	
	LS MM	Share %	LS MM	Share %	LS MM	Share %	LS MM	Share %	LS MM	Share %	LS MM	Share %	LS MM	Share %	LS MM	Share %	LS MM	Share %
Agriculture	176.2	33.0	194.0	33.9	203.9	33.2	209.2	32.3	219.1	31.9	243.8	32.4	334.6	38.4	516.4	41.5	585.3	38.7
Manufacturing and Mining	49.4	9.3	54.9	9.7	57.3	9.3	66.8	10.3	69.2	10.1	76.8	10.2	82.9	9.2	111.2	8.9	142.9	9.5
Electricity and Water	16.6	3.1	16.3	2.8	16.6	2.7	16.5	2.6	16.6	2.4	16.9	2.2	17.5	2.0	18.6	1.5	20.9	1.4
Construction & Building	23.9	4.5	22.8	4.0	24.4	4.0	24.3	3.8	23.3	3.4	26.2	3.5	31.2	3.5	61.0	4.9	65.0	4.3
Wholesale Trade, Finance, Real-estate, etc.	154.0	28.0	162.7	28.4	178.9	29.1	146.4	22.6	158.6	23.1	179.8	23.9	197.0	22.0	271.5	21.8	354.4	23.4
Transport & Communication	33.4	6.3	33.6	5.9	36.1	5.9	51.1	7.9	50.7	7.4	51.3	6.8	61.5	6.9	74.8	6.0	89.4	5.9
Sub Total	453.5	85.1	484.3	84.6	517.2	84.2	514.3	79.5	537.5	78.4	595.0	79.1	734.7	82.0	1,053.6	84.5	1,257.9	83.2
Government Services	44.4	8.3	50.7	8.9	53.3	8.7	81.5	12.6	87.4	12.7	98.2	13.1	104.8*	11.7	127.9	10.3	151.2	10.0
Customs & Others	35.5	6.6	37.3	6.5	43.4	7.1	51.2	7.9	60.9	8.9	58.9	7.8	57.3	6.3	64.7	5.2	101.7	6.8
Total GDP 1)	533.4	100.0	572.3	100.0	613.9	100.0	647.0	100.0	685.8	100.0	752.1	100.0	896.8	100.0	1,246.2	100.0	1,510.8	100.0
Price Index % 2)							100.0		107.5		118.2		137.6		172.2		211.1	
GDP at Constant Price 3)							647.0		638.0		636.3		651.7		723.7		715.7	

Source: Dept. of Statistics, June 1977

Notes: * This figures does not contain the workers compensation in the southern region government.
1) Current price is used instead of factor cost in this publication.
2) Price index of the cost of living (1970-75) is applied in this Table. The index is quoted from the Economic Survey, 1975/76, Ministry of Planning
3) The constant price as in 1970 was derived by dividing 1) by 2). It is calculated that GDP has grown at 2.0% p.a. in terms of constant price.

ANNEX III-10

TABLE 3-10 THE BALANCE OF PAYMENTS

(LS Million)

	1971/72 Actual	1972/73 Actual	1973/74 Actual	1974/75 Actual	1974/76 Prov. Actual [1]
(A) The Current Account					
(1 + 2 + 3)	- 30.9	- 1.5	- 30.5	-160.3	-178.9
1. Exports	102.4	127.6	142.8	157.8	183.3
Cotton	55.3	71.7	73.8	63.1	90.0
Others	47.1	55.9	69.0	94.7	93.3
2. Imports	121.4	113.1	149.6	280.0	341.8
Government Purchases	37.3	39.8	48.1	137.7	211.8
Private Sector Imports	84.1	73.3	101.5	142.3	130.0
Trade Balances (1-2)	- 19.0	14.5	- 6.8	-122.2	- 15.8
3. Invisible Account (net)	- 11.9	- 16.0	- 23.7	- 38.1	- 20.4
Receipts	16.4	16.4	17.8	28.9	39.6
Payments	28.3	32.4	41.5	67.0	60.0
(B) Capital Account (net)	8.1	2.6	16.8	108.6	110.0
Drawings	20.1	17.9	41.3	111.5	142.0
Repayments	12.0	15.3	18.2	13.3	32.0
Compensations for Nationalized Companies	-	-	6.3	-	-
External Assets of SDC	-	-	-	10.4	-
(C) Errors and Omissions	2.6	- 1.8	- 1.5	0.2	-
(D) Balance of Payments	- 20.2	- 0.7	- 15.2	51.9	- 68.9

Source: Bank of Sudan (Economic Survey, 1975/76)

Note: 1) Preliminary estimates

TABLE 3-11 QUANTITY AND VALUE OF MAIN EXPORTS DURING 1971-75

ANNEX III-11

(Quantity in Metric Ton, Value in LS Million)

	1971		1972		1973		1974		1975	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Cotton	294,585	69,906	256,315	73,088	743,726	84,311	78,646	43,202	156,652	70,193
Gum Arabic	41,971	8,030	40,758	8,729	33,941	7,403	19,987	14,157	15,643	7,548
Sesame	84,442	7,997	85,197	8,810	101,863	10,706	83,508	16,511	56,624	11,939
Groundnuts	115,061	9,327	113,740	9,637	138,425	12,993	99,052	18,163	204,960	34,382
Cotton Seed	49,770	1,468	21,815	611	14,987	530	4,562	253	-	-
Dura	32,428	1,085	7,032	1,646	93,953	2,922	89,217	3,401	45,084	2,233
Hides and Skins	8,829	1,938	5,991	3,011	8,159	6,072	5,276	3,777	6,040	3,187
Others	-	14,683	-	17,702	-	27,235	-	21,486	-	22,980
Total	-	114,374	-	123,234	-	152,172	-	122,010	-	152,468

Source: Bank of Sudan (Ministry of Planning, Economic Survey, 1975/76)

TABLE 3-12 IMPORTS BY COMMODITY

(Value in LS Million)

	1971	1972	1973	1974	1975
Food Stuffs	21.65	27.55	33.93	56.47	60.45
Drinks and Tobacco	3.00	3.95	2.32	3.20	4.26
Crude Materials	3.37	1.55	1.52	33.98	28.20
Chemicals	12.88	14.30	18.95	27.21	40.16
Manufactured Goods	24.57	24.12	33.61	38.73	60.16
Machinery and Equipment	14.19	15.93	20.00	20.09	59.14
Transport Equipment	11.45	13.40	25.29	33.68	64.47
Textiles	25.33	16.91	16.23	24.15	43.06
Total	116.44	117.91	151.85	247.54	359.90

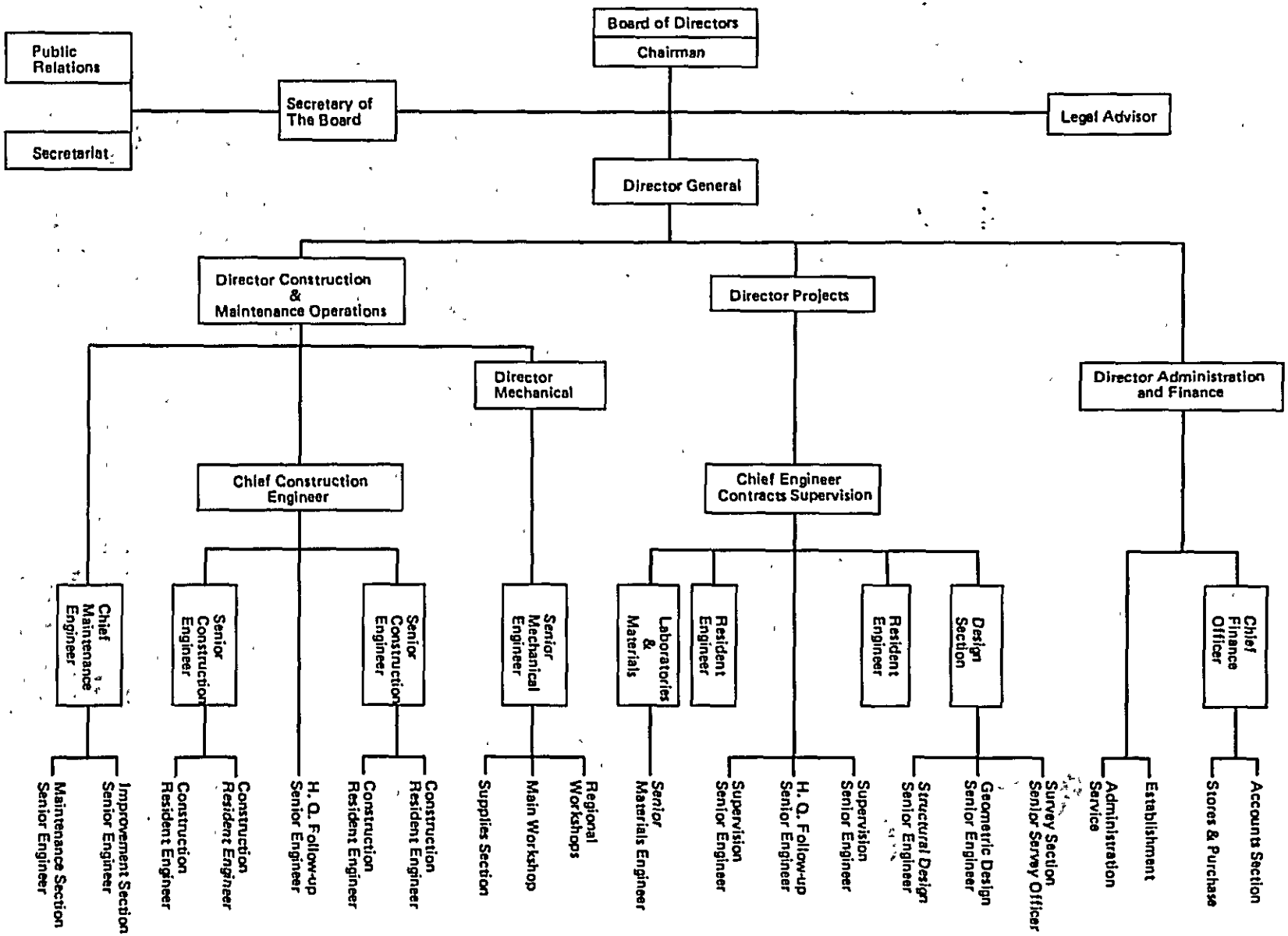
Source: Bank of Sudan (Economic Survey, 1975/76)

TABLE 3-13 SUDAN AIRWAYS PASSENGER AND FREIGHT TRAFFIC

Period	Passenger Traffic (Number of Passengers) ('000)				Total Freight Traffic (Ton)			
	International	Domestic	Total	Index	International	Domestic	Total	Index
1965/66	N.A.	N.A.	96	100	N.A.	N.A.	1.633	100
1966/67	N.A.	N.A.	102	106	N.A.	N.A.	1.386	84
1967/68	54	37	91	94	0.685	.797	1.482	90
1968/69	68	56	124	129	0.710	.844	1.554	95
1969/70	70	54	124	129	0.797	.855	1.652	101
1970/71	87	55	142	147	0.713	.708	1.421	87
1971/72	72	63	135	140	0.590	.750	1.340	82
1972/73	131	93	224	233	1.510	.788	2.298	140
1973/74	136	94	230	239	2.337	.893	3.230	197

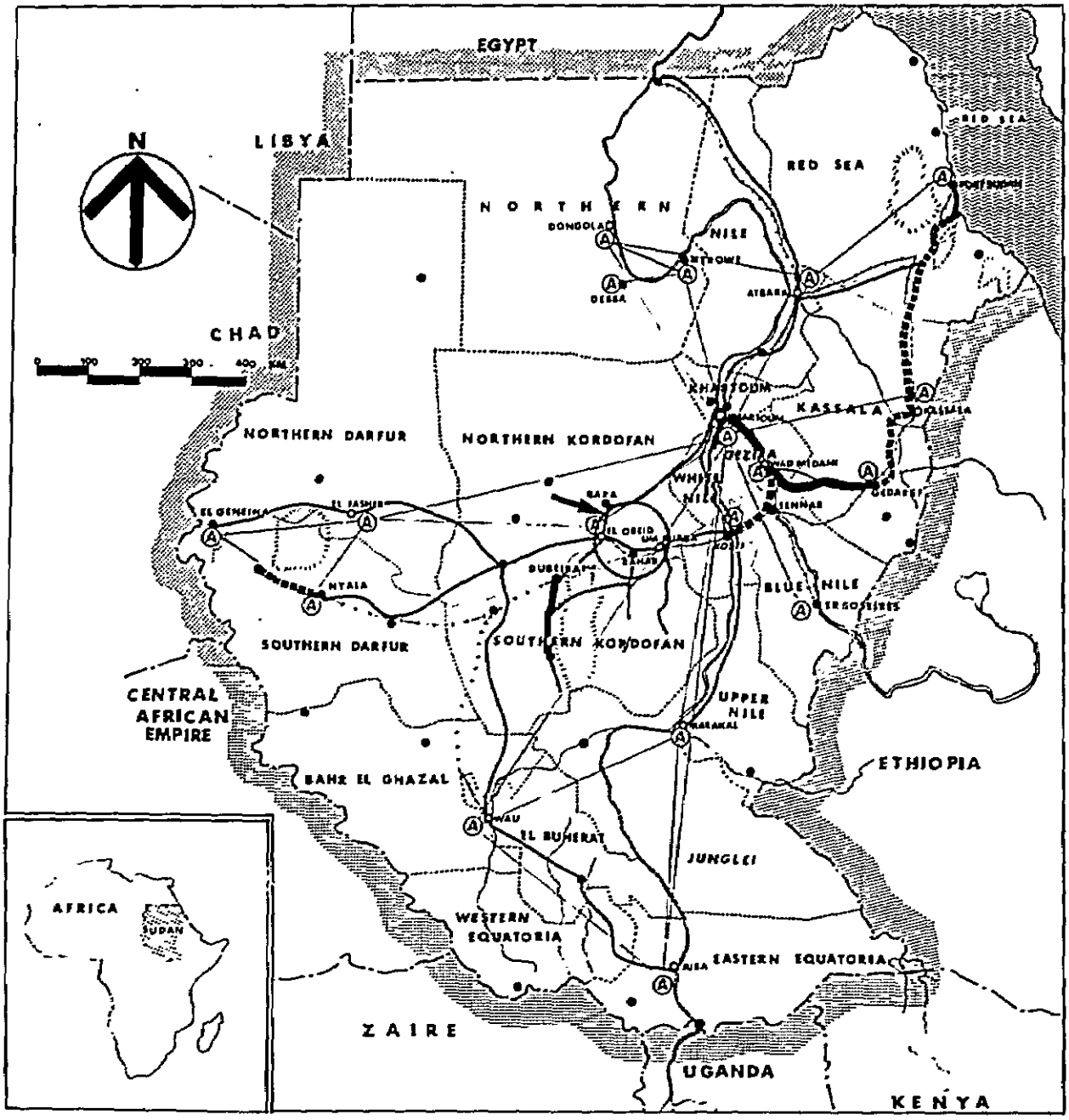
Source: Sudan Airways Financial and Statistical Reports,(Transport Statistical Bulletin, 1974)

FIG.3-1 ROADS AND BRIDGES PUBLIC CORPORATION ORGANIZATIONAL CHART 1977



ANNEX III-15

FIG. 3-2 TRANSPORTATION NETWORK, SUDAN



LEGEND

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

TABLE 3-14 ROADS IN RBPC

	Length in km	
Paved Roads [1]		756
Khartoum-Wad Medani Road	187	
Wad Medani - Gedaref Road	227	
Port Sudan - Suakin Road	57	
Khartoum North - El Gaili Road	42	
Khartoum - Jebel Aulia Road	36	
Omdurman - Wadi Saidna Road	21	
Dubeibat - Dilling - Kadugli Road	186	
Under Construction Roads [1]		936
Gedaref - Kassala Road	220	
Kassala - Haiya Road	350	
Haiya - Suakin Road	149	
Wad Medani - Sennar - Kosti Road	217	
Completely Designed and Waiting for Financing Roads		1,026
Nyala - Kas - Zalingei Road	210	
Jebel Aulia - Ed Dueim - Rabak Road	260	
Sennar - Suki - El Roseires Road	233	
Gedaref - Doka - Gallabat Road	154	
El Obeid - Dubeibat Road	94	
Kassala - Sabderat	75	
Under Feasibility Study Roads		1,121
Gedaref - Um Barakat Road	110	
Wad El Huni - Simsim Road	77	
Gedaref - Suki Road	178	
Rabak - Renk Road	166	
El Obeid - Um Ruaba Road	150	
Kadugli - Talodi Road	100	
Juba - Torit - Lodwar Road	340	
Proposed Roads Projects		4,559
Kosti - Um Ruaba Road	170	
Juba - Minule - Gubu Road	281	
Zalingei - El Geneina - Adre Road	193	
Port Sudan - Bernis Road	508	
or		
Omdurman - Dongola - Halfa Road	547	
Renk - Malakal - Juba Road	851	
El Obeid - En Nahud Road	235	
En Nahud - El Fasher Road	452	
El Fasher - Nyala Road	225	
Talodi - Malakal Road	246	
Kadugli - Wau Road	-	
Khartoum - Kassala Road	401	
Khartoum - Atbara Road	312	
Renk - El Roseires Road	-	
Wad Medani - Ed Dueim Road	138	

Source: RBPC, Sudan, June 1977

Note: 1) RBPC is initially responsible for these roads.

TABLE 3-15 LICENCED MOTOR VEHICLES

Year	TYPE OF VEHICLE						
	Passenger Cars	Buses	Lorries	Delivery Vans Box Cars	Tractors Motorcycles	Others	Total
1970	25,387	2,003	10,817	7,770	2,030	802	49,484
1971	28,026	2,015	12,677	7,139	1,717	554	52,797
1972	29,407	2,782	15,813	7,819	2,259	660	59,450
1973	33,061	2,664	21,549	21,549	3,107	2,217	62,464
1974	38,143	3,137	22,908	11,227	2,543	1,121	79,079
Average Annual Growth Rate (%)	10.2	11.7	20.6	9.6	5.8	8.7	12.4

Source: Transport Statistical Bulletin, 1975

TABLE 3-16-1 GASOLINE AND BENZINE CONSUMPTION IN THE SUDAN [1]

('000 Tons)

Year	Gasoline (Diesel)	Benzine (Gasoline)	Total
1970	271	95	366
1971	298	97	395
1972	301	101	402
1973	323	105	428
1974	329	106	435
1975	349	116	465
1976 [2]	391	131	522
Average Annual Growth Rate (%)	6.3	5.5	6.1

Sources: 1) Transport Statistical Bulletin, 1975

2) Shell Company of the Sudan, June 1977

TABLE 3-16-2 GASOLINE AND BENZINE CONSUMPTION ON ROADS

('000 Tons)

Year	Gasoline (Diesel)	Benzine (Gasoline)	Total
1970	110	95	205
1971	121	97	218
1972	128	101	229
1973	129	105	234
1974	132	106	238
1975	140	116	256
Average Annual Growth Rate (%)	4.9	4.1	4.5

Source: Transport Statistical Bulletin, 1975

ANNEX III-19

TABLE 3-17 RAIL PASSENGERS BY CLASS OF TRAVEL [1]

('000 persons)

Year	Sleeper (Suppl.)	1st Class	2nd Class	3rd and 4th Class	All Classes
1970/71	20.3	65.5	192.2	3,139.2	3,417.2
1971/72	18.7	54.6	172.5	2,996.1	3,241.9
1972/73	28.4	87.6	236.4	3,029.8	3,382.8
1973/74	24.9	69.9	199.0	2,513.4	2,807.2
1974/75	24.9	79.4	233.9	2,608.6	2,946.5
1975/76 [2]	30.0	111.1	232.1	2,696.0	3,069.2

Sources: 1) Transport Statistical Bulletin, 1975

2) Sudan Railways Corporation, Annual Report, 1975/76

ANNEX III-20

TABLE 3-18 SUDAN RAILWAYS TRAFFIC BY TYPE [1]

('000 tons)

Year	Exported Traffic	Imported Traffic	Local Traffic	Livestock Equivalent	Total
Actual 1969/70	843	1,384	725	53	3,005
1970/71	872	1,532	618	40	3,062
1971/72	923	1,460	505	20	2,908
1972/73	854	1,421	495	30	2,800
1973/74	697	1,379	477	28	2,581
1974/75	644	1,312	433	11	2,400
1975/76 [2]	815	1,494	346	16	2,673

Sources: 1) Transport Statistical Bulletin, 1975

2) Sudan Railways Corporation, Annual Report, 1975/76

ANNEX IV

ANNEX IV-1

TABLE 4-1 POPULATION AND GROWTH RATE, KORDOFAN PROVINCE AND THE SUDAN

	Population 1955/56	Population 1973	Growth Rate per year (%)	Sources
Sudan Total	10,262,500	14,958,000	2.24	Department of Statistics, Ministry of National Planning, 1977
- " -	10,262,500	14,901,894	2.22	National Planning Commission, Sudan, Economic Survey, 1974
Kordofan Province	1,762,000	2,202,346	1.32	- " -
- " -	1,762,000	2,099,121	1.04	Statistics Department, Northern Kordofan Province

TABLE 4-2 URBAN POPULATION IN NORTHERN AND SOUTHERN KORDOFAN PROVINCES

Town	1964/66 Census 1) Permanent Member of Private Household	Persons Present (A)	of which In Private Households	of which In Institutes	1973 Urban Persons Present 2) (B)	Urban Population Growth Rate per Year (A) to (B)
Northern Kordofan Province						
El Obeid	62,560	63,831	62,984	847	90,073	
En Nahud	19,770	20,038	19,220	818	26,005	
Um Ruaba	14,210	14,392	13,910	482	19,713	
Rahad	8,600	8,924	8,590	334	14,444	
Bara	6,140	6,431	6,060	371	8,927	
Sodiri	2,820	3,046	2,880	166	2,674	
Abu Zabad 3)	5,660	5,939	5,470	469	7,177	
Sub Total	119,760	122,601	119,114	3,487	169,013	4.10%
Southern Kordofan Province						
Dilling	11,910	12,696	11,890	806	19,216	
Kadugli	11,180	11,532	10,960	572	18,468	
Abu Korshola	5,120	4,970	4,860	110	5,274	
El Abassiya	4,470	4,667	4,420	247	4,801	
Muglad	4,270	4,709	4,180	529	6,936	
Talodi	4,030	4,250	4,100	150	7,738	
Rashad	3,260	3,555	3,260	295	3,588	
Babanousa 3)	7,460	7,092	6,760	332	12,051	
Abu Gebaha 3)	5,180	5,419	5,110	309	10,418	
Rigl El Foula 3)	3,750	4,131	3,610	521	5,294	
Sub Total	60,630	63,021	59,150	3,871	93,784	5.10%
All Towns Total	180,390	185,622	178,264	7,358	262,797	4.44%

Notes: 1) Dept. of Statistics, Sudan. Population and Housing Survey, Urban Areas, Kordofan Province, 1964/66. (Khartoum, 1968)
2) Statistics Dept. of Northern Kordofan Province.
3) These towns were included in rural areas at the 1964/66 census.

TABLE 4-3 DISTRICT POPULATION OF NORTHERN AND SOUTHERN KORDOFAN PROVINCES, 1973

Province & District	Population Settled			Nomad	Total
	Urban	Rural	Sub Total		
Northern Kordofan Province					
Central Dist.	90,073	94,446	184,519	4,973	189,492
Eastern Dist.	34,157	281,481	315,638	20,634	336,272
Western Dist.	33,182	296,530	329,712	9,486	339,198
Northern Dist.	8,927	135,880	144,807	14,762	159,569
North-Western Dist.	2,674	63,851	66,525	137,523	204,048
Free Lance	-	-	-	67,509	67,509
Total	169,013	872,188	1,041,201	254,887	1,296,088
%	13.0	67.3	80.3	19.7	100.0
Southern Kordofan Province					
Miosaria Dist.	24,281	148,074	172,355		
Northern Hills Dist.	19,216	151,597	170,813	99,266	
Southern Hills Dist.	26,206	206,674	232,880		
Tagali Dist.	24,081	171,147	195,228		
Free Lance	-	-	-	35,716	
Total	93,784	677,492	771,276	134,982	906,258
%	10.3	74.8	85.1	14.9	100.0

Source : Statistics Dept., Northern Kordofan Province, Eastern Kordofan District Office and the Dept. of Statistics, Sudan Government.

TABLE 4-4 POPULATION AND ITS GROWTH RATE IN URBAN AND RURAL AREAS OF NORTHERN AND SOUTHERN KORDOFAN PROVINCES, 1955/56-1977

	1955/56 Census (1956)		1964/66 Urban Census (1966)		1973 Census	1977 Estimate
(1) Population in Both Provinces	1,762,000[1]				2,202,346[1]	2,321,044
Annual Growth Rate			1.321%		1.321%	
(2) Urban Population	123,340		185,622[2]		262,797[2]	312,792
Annual Growth Rate		4.65%		4.44%	4.44%	
a. Northern Kordofan Urban Area			122,601[2]		169,013[3]	198,406
Annual Growth Rate				4.09%	4.09%	
b. Southern Kordofan Urban Area			63,021[2]		93,784[3]	114,386
Annual Growth Rate				5.09%	5.09%	
(3) Rural Population including Nomads	1,638,660				1,939,549	2,008,252
Annual Growth Rate			1.00%		0.874%	
a. Northern Kordofan Rural Area					1,127,075	1,166,999
b. Southern Kordofan Rural Area					812,474	841,253
Annual Growth Rate					0.874%	

Sources: 1) National Planning Commission, Economic Survey, 1974 (Sudan, 1975).
2) Population and Housing Survey, Urban Area, Kordofan Province, 1964/66.
3) Northern Kordofan Province Government.

ANNEX IV-5 ESTIMATE OF POPULATION IN THE ZONES

The number of villages in each zone was counted on the photo mosaic at 1 : 48,000 produced in 1962, the map at 1 : 250,000 revised in 1975, and the photo mosaic at 1 : 25,000 produced by the JICA's study team in 1977. To classify the villages three classes were established: 80 houses for the smallest, 150 houses for the second class, and a figure in the range of 214 to 700 for each of the largest villages. The results of these studies are shown in the following Table.

TABLE 4-5-1 NUMBER OF VILLAGES

Zone	Urban Area	Number of Villages			Total
		Large	Medium	Small	
1	El Obeid	-	1	33	34
2	-	2	-	28	30
3	-	1	2	21	24
4	-	1	7	13	21
5	Um Ruaba	-	2	41	43
6	-	1	2	16	19
7	-	2	2	19	23
8	Rahad	1	-	28	29
9	-	-	1	15	16
10	-	4	-	7	11
Total	3	12	17	221	250

Assuming a house is occupied by a family of five persons, the number of inhabitants in each zone is estimated in Table 4-5-2, as shown below.

TABLE 4-5-2 POPULATION BY ZONE

Zone No.	Urban	Rural	Total
1	105,738	13,950	119,668
2	-	13,340	13,340
3	-	10,970	10,970
4	-	13,950	13,950
5	23,141	17,900	41,041
6	-	9,614	9,614
7	-	12,922	12,922
8	16,956	12,270	29,226
9	-	6,750	6,750
10	-	12,800	12,800
Total	145,835	124,466	270,301

By 1955/56 census, the ratio of urban population to total population was 7.0 percent and labourers in the agriculture sector comprised 85.8 percent of the total labour force (economically active population). Also, it was found that a family in the urban area averaged 5.5 persons, that families settled in a rural area had 4.9 persons, and that nomad families averaged 5.7 persons at that time. The average of the country as a whole was 5.1 persons per family. It was estimated that the population in the agriculture sector was 8,806,000, or 85.5 percent of the total population.

Since the rural population including nomads numbered 9,545,000, the population in the agriculture sector totaled 92.3 percent. By taken from other sources for 1970 and 1973, it is estimated that agricultural population embraces 85 percent of the rural population of the Sudan in 1977. When this percentage figure is applied to Northern Kordofan Province the following Table 4-5-3 results.

TABLE 4-5-3 RURAL AND AGRICULTURAL POPULATION IN NORTHERN KORDOFAN PROVINCE

	Rural Population Including Nomad (1)	Agricultural Population (1) x 0.85 (2)	Nomad (3)	Agricultural Population Settled (2)-(3)	Rural Population Settled (4)=(1)-(3)	(2)-(3)/(4) (%)
Central Dist.	102,941	87,500	5,149	82,351	97,792	84.2
Eastern Dist.	312,816	265,894	21,365	244,529	291,451	83.9
Sub-Total	415,757	353,394	26,514	326,880	389,243	84.0
Northern K. Province	1,166,999	991,949	213,916	778,033	903,083	86.1

The average ratio of agricultural population in both districts is 84.0 percent in the above Table. By applying this ratio, the population in each zone is established and is presented in the follosing Table 4-5-4 and Table IV-2.

TABLE 4-5-4 SETTLED POPULATION BY ZONE, 1977

Zone	Rural Population Settled *	Agricultural Population Settled * x 0.84	Farm Households (Families)
1	13,950	11,718	2,344
2	13,340	11,206	2,241
3	10,970	9,215	1,843
4	13,950	11,718	2,344
5	17,900	15,036	3,007
6	9,614	8,076	1,615
7	12,922	10,854	2,171
8	12,270	10,307	2,061
9	6,750	5,670	1,134
10	12,800	10,752	2,150
Total	124,466	104,552	20,910

TABLE 4-6 AGRICULTURAL AND FORESTRY PRODUCTS IN NORTHERN KORDOFAN PROVINCE

	Dukhn			Dura			Sesame			Groundnuts			Watermelon Seeds		
	Area (feddan)	Yield (kg/f.)	Production (ton)	Area (feddan)	Yield (kg/f.)	Production (ton)	Area (feddan)	Yield (kg/f.)	Production (ton)	Area (feddan)	Yield (kg/f.)	Production (ton)	Area (feddan)	Yield (kg/f.)	Production (ton)
1970	718,046	196	140,955	476,046	162	77,309	1,061,370	143	152,098	244,569	172	41,949			
1971	1,157,342	150	185,726	559,877	145	81,256	1,008,058	81	82,151	840,597	91	76,420			
1972	1,564,925	68	106,699	731,831	137	100,029	1,778,940	91	161,722	810,597	91	73,690			
1973															
1974	1,250,000	90	112,500	685,224	140	95,931	923,800	70	64,670	578,830	320	185,230	410,430	97	39,812
1975	1,257,000	100	125,700	672,954	140	94,214	950,000	75	71,290	593,930	375	222,720	382,718	97	37,124
1976	1,353,000	145	196,000	631,000	200	126,000	900,000	70	63,000	418,000	375	157,000	389,885	90	35,090
Average	1,216,719	119	114,597	626,155	153	95,790	1,103,695	90	99,155	581,087	217	126,168	394,344	95	37,342

	Karkadeh			Sanamakar			Gum Arabic					Cotton			Charcoal [1]	Firewood [1]	
							Area		Production							Private Products	Government Products
	Area (feddan)	Yield (kg/f.)	Production (ton)	Area (feddan)	Yield (kg/f.)	Production (ton)	Estimate (feddan)	Yield (kg/f.)	Hashab (ton)	Talh (ton)	Total	Area (feddan)	Yield (kg/f)	Production (ton)	(ton)	(m^3)	(m^3)
1970							312,240	50	14,667	945	15,612						
1971							350,900	50	16,950	595	17,545	2,063	89	184	12,000	3,300	2,500
1972							287,400	50	11,496		14,370	3,000	163	489			
1973							134,600	50	6,730		6,730						
1974	47,481	13	617	6,842	540	3,695											
1975	44,095	13	573	2,460	540	1,328											
1976	20,276	10	203	6,482	540	3,500	133,000	50			6,650						
Average	37,284	12	464	5,261	540	2,841	243,628	50			12,181	2,532	133	337	12,000	3,300	2,500

Note: 1) Approximately estimated by taking half of the production of Northern and Southern Kordofan Provinces. The statistical data registering the production in both Kordofan Provinces in 1971 are as follows: Charcoal, 23,750 tons, Firewood - private; 6,601 m^3, Government; 5,000 m^3.

Sources: Sudan Yearbook of Agricultural Statistics, 1974; Current Agricultural Statistics CAS-Vol. 1, No.2, 1976; H.M. AWOUDA, Forest Department, Production & Supply of Gum Arabic 1970-1971; Statistics Dept. of Northern Kordofan Prov.; and Dept. of Agricultural Economics and Statistics, Ministry of Agriculture, Khartoum.

TABLE 4-7 LIVESTOCK IN TWO DISTRICTS, 1976

(Heads)

		Rainy Season	Dry Season
Central Kordofan District 1)	Cattle	156,000	81,000
	Sheep	125,000	64,000
	Goats	109,000	56,000
	Camels	8,000	4,000
	Donkeys	3,000	2,000
	Horses	4,000	2,000
	Total	405,000	209,000
Eastern Kordofan District 2)	Cattle	250,000	75,000
	Sheep	125,000	17,500
	Goats	200,000	150,000
	Camels	130,000	100,000
	Total	705,000	342,500

Sources: 1) Acting Commissioner for Animal Resources, Northern Kordofan Province, El Obeid.

2) District Veterinary Office, Eastern District Northern Kordofan Province, Rahad.

TABLE 4-8 LIVESTOCK TRADED

(Heads)

CENTRAL KORDOFAN DISTRICT ANIMAL MARKETS, JAN.-MAR. 1977 a)

	Jan. 1977		Feb. 1977		Mar. 1977		Total Jan.-Mar.	
	Brought	Sold	Brought	Sold	Brought	Sold	Brought	Sold
Cattle	3,590	1,331	3,899	213	2,749	1,074	10,238	2,618
Sheep	10,051	6,387	8,233	5,467	7,185	5,509	25,469	17,363
Goats	482	294	-	-	699	132	1,181	426
Camels	1,023	162	1,591	134	960	89	3,574	385
Donkeys	1,193	336	1,175	269	897	191	3,265	796
Horses	121	46	119	24	121	73	361	143
Total	16,460	8,556	15,017	6,107	12,611	7,068	44,088	21,731

UM RUABA ANIMAL MARKET 1973/74 - 75/76 b)

	1973/74		1974/75		1975/76	
	Brought	Sold	Brought	Sold	Brought	Sold
Cattle	700	500	5,750	3,594	13,980	11,070
Sheep	1,900	1,400	4,250	3,466	29,300	19,750
Goats	1,000	750	910	546	9,120	2,230
Total	3,600	2,650	10,910	7,606	52,400	33,050

CENTRAL KORDOFAN DISTRICT SLAUGHTER HOUSES a)

	Slaughtered		Prices Registered 1)
	74/75	75/76	
Cattle	24,647	24,058	46.50
Cows	5,218	7,223	
Sheep	51,598	81,602	7.50
Goats	6,919	9,409	4.00
Camels	1,340	991	80.00
Total	89,722	123,283	

Sources: a) Acting Commissioner for Animal Resources, Northern Kordofan Province, El Obeid.
b) District Veterinary Office, Eastern District Northern Kordofan Province, Rahad.
The volumes traded at Rahad animal market is said to be one-third of those traded at Um Ruaba animal market.

Note: 1) Prices are an average LS per head March, 1977.

TABLE 4-9 CROP PRODUCTION ESTIMATES IN THE ZONES OF THE PROJECT AREA, 1977

Unit: Area - feddan
Product - ton

Crop / Zone	Dukhn		Dura		Sesame		Groundnuts		Watermelon Seeds		Karkadeh		Sanamakar		Gum Arabic	
	Area	Product	Area	Product	Area	Product	Area	Product	Area	Product	Area	Product	Area	Product	Area	Product
1	19,488	2,341	9,905	1,486	13,807	1,036	7,954	2,784	5,928	563	555	7	75	40	2,026	101
2	18,618	2,237	9,463	1,420	13,191	989	7,599	2,660	5,663	538	530	6	72	39	1,936	97
3	15,312	1,840	7,783	1,167	10,849	814	6,250	2,187	4,658	442	436	5	59	32	1,592	80
4	19,488	2,341	9,905	1,486	13,807	1,036	7,954	2,784	5,928	563	555	7	75	40	2,026	101
5	25,056	3,010	12,735	1,910	17,752	1,331	10,227	3,580	7,622	724	714	8	96	52	2,605	130
6	13,398	1,610	6,810	1,022	9,493	712	5,469	1,914	4,076	387	382	5	52	28	1,393	70
7	18,096	2,174	9,198	1,380	12,821	962	7,386	2,585	5,505	523	516	6	70	38	1,881	94
8	17,226	2,069	8,756	1,313	12,205	915	7,031	2,461	5,240	498	491	6	66	36	1,791	90
9	9,396	1,129	4,776	716	6,657	499	3,835	1,342	2,858	272	268	3	36	20	977	49
10	17,922	2,153	9,109	1,366	12,698	952	7,315	2,560	5,452	518	511	6	69	37	1,863	93
Total	174,000	20,904	88,440	13,266	123,280	9,246	71,020	24,857	52,930	5,028	4,958	59	670	362	18,090	905

Note: The distribution of cultivated area by zone is calculated by the percentage distribution of farm households among the zones.

TABLE 4-10 PRODUCER'S PRICES IN CROP MARKETS IN EL OBEID AND EASTERN KORDOFAN DISTRICT

Products and Markets	1974/75 LS/Kg	(LS/Kantar)	1975/76 LS/Kg	(LS/Kantar)	1976/77 LS/Kg	(LS/Kantar)	Producer's Price 1977 LS/Kg	(LS/Kantar)
Dukhn								
El Obeid	----------		----------		0.093	(4.200)	0.093	(4.200)
Dura								
El Obeid	----------		----------		0.055	(2.500)	0.055	(2.500)
Sesame								
El Obeid	0.125	(5.632)	0.125	(5.624)	0.102	(4.600)		
Eastern Kordofan (14 markets)	0.119	(5.370)	0.118	(5.300)	----------		0.111	(5.000)
Groundnuts								
El Obeid	0.078	(3.507)	0.077	(3.467)	0.071	(3.200)		
Eastern Kordofan (14 markets)	0.071	(3.187)	0.071	(3.190)	----------		0.071	(3.200)
Watermelon . Seeds								
El Obeid	0.054	(2.414)	0.066	(2.936)	0.093	(4.200)		
Eastern Kordofan (14 markets)	0.044	(1.995)	0.021	(0.934)	----------		0.089	(4.000)
Karkadeh								
El Obeid	0.144	(6.484)	0.116	(5.228)	0.333	(15.000)		
Eastern Kordofan (14 markets)	0.158	(7.127)	0.123	(5.535)	----------		0.222	(10.000)
Gum Arabic								
El Obeid	0.406	(18.250)	0.272	(12.250)	0.208	(9.353)		
Eastern Kordofan (14 markets)	0.345	(15.547)	0.191	(8.605)	----------		0.200	(9.000)

Source: El Obeid and Um Ruaba crop markets, 1977

TABLE 4-11 CROP PRODUCTION AND INCOME PER FARM HOUSEHOLD IN THE DIRECT INFLUENCE ZONE

	Area feddan	Total Production kg	Home Consumption a) Net Food kg/Farm 1)	Feed kg	Waste 1) kg	Seed kg	Total Quantity kg	Value LS 2)	Sales Quantity kg	Sales Value LS 3)
Dukhn	8.3	1,000.0	245.0	-	50.0	58.0	353.0	29.546	647.0	54.154
Dura	4.2	634.0	472.5	11.4	29.4	15.0	528.3	26.151	105.7	5.232
Sesame	6.0	442.0	116.0	-	15.0	30.0	161.0	16.084	281.7	28.072
Groundnuts (in shell)	3.4	1,189.0	158.0	-	120.0	272.0	550.0	35.145	639.0	40.832
Watermelon Seeds	2.5	240.0	-	-	-	-	-	-	240.0	19.224
Karkadeh	0.24	3.0	-	-	-	-	-	-	3.0	0.599
Sanamakar	0.03	17.0	-	-	-	-	-	-	17.0	-
Gum Arabic	0.87	43.0	-	-	-	-	-	-	43.0	7.740
(Fallow Land)	3.36	-	-	-	-	-	-	-	-	-
Total	28.9	3,568.0	991.5	11.4	214.4	375.0	1,592.3	106.926	1,975.7	155.853

Source: a) Estimate based on the data provided by Current Agricultural Statistics, (Ministry of Agriculture) June, 1976.

Notes: 1) Assumed each family has five persons.
2) Unit values are determined ten percent less than the price in Annex IV-10 to cover transport cost and losses.
3) Settled farmers have few animals with which they can earn cash income. Majority of livestock is held by nomads. Therefore, earnings by selling livestock by settled farmers is not included in this table.

TABLE 4-12 UNIT YIELD OF MAIN CROPS

(kg/feddan)

	Dura		Dukhn		Sesame		Groundnuts	
	Whole Sudan	North[2] Kordofan	Whole Sudan	North[2] Kordofan	Whole Sudan	North[2] Kordofan	Whole Sudan	North[2] Kordofan
1970/71 [1]	314	162	253	196	160	143	371	172
1971/72 [1]	349	145	210	150	154	81	256	91
1972/73 [1]	317	137	139	68	119	91	346	91
1974/75 [3]	306	150	156	90	107	70	519	320
1975/76 [3]	327	164	161	100	104	75	451	375
1970/71-1974/75 Average	323	152	184	121	129	92	389	210

Sources: 1) National Planning Commission, Economic Survey, 1974.

2) Ministry of Agricultural, Food and Natural Resources (MIN. AFNR), Yearbook of Agricultural Statistics, 1974.

3) MIN. AFNR, Current Agricultural Statistics, June 1976.

ANNEX IV-13 EL OBEID AIRPORT RUNWAY CONSTRUCTION

The existing airport at El Obeid has two gravel surfaced runways of 1,800 m and 1,300 m. Normally, Sudan Airways flies F27s and B737s in and out of this airport. The apron, terminal building, landing instruction system, etc. are all obsolete.

The urgent necessity to improve the airport facility is recognized by the government. Accuracy of flight schedules, maintenance of flight safety and the use of larger aircraft are required and are of high priority.

Under the circumstances, the new runway construction is being carried out as one improvement project (see below).

New Runway:	2,500 m in length and 45 m in width.
1st Stage:	The formation of runway structures, up to base course and drainage system, by June, 1977.
2nd Stage:	Asphalt surfacing of runway by December, 1978.
Total Cost:	LS 1.5 million at 1976 price level.

ANNEX IV-14 EL AIN DAM CONSTRUCTION

The existing water reservoirs at El Ain are not sufficient to supply the water requirements of the populace in El Obeid. At present, the maximum capacity is about 3.5 million m^3. Thus, the people in El Obeid have been suffering from a constant water shortage, except for a few months during the rainy season.

The Rural Water Supply Corporation of the Sudan is in direct charge of the expansion programme of the water system. The project consists of the construction of new dams with a pondage of 2 million m^3, located close to the existing dams at Khor El Baggara, and the installation of a new pipeline of 30 km to El Obeid.

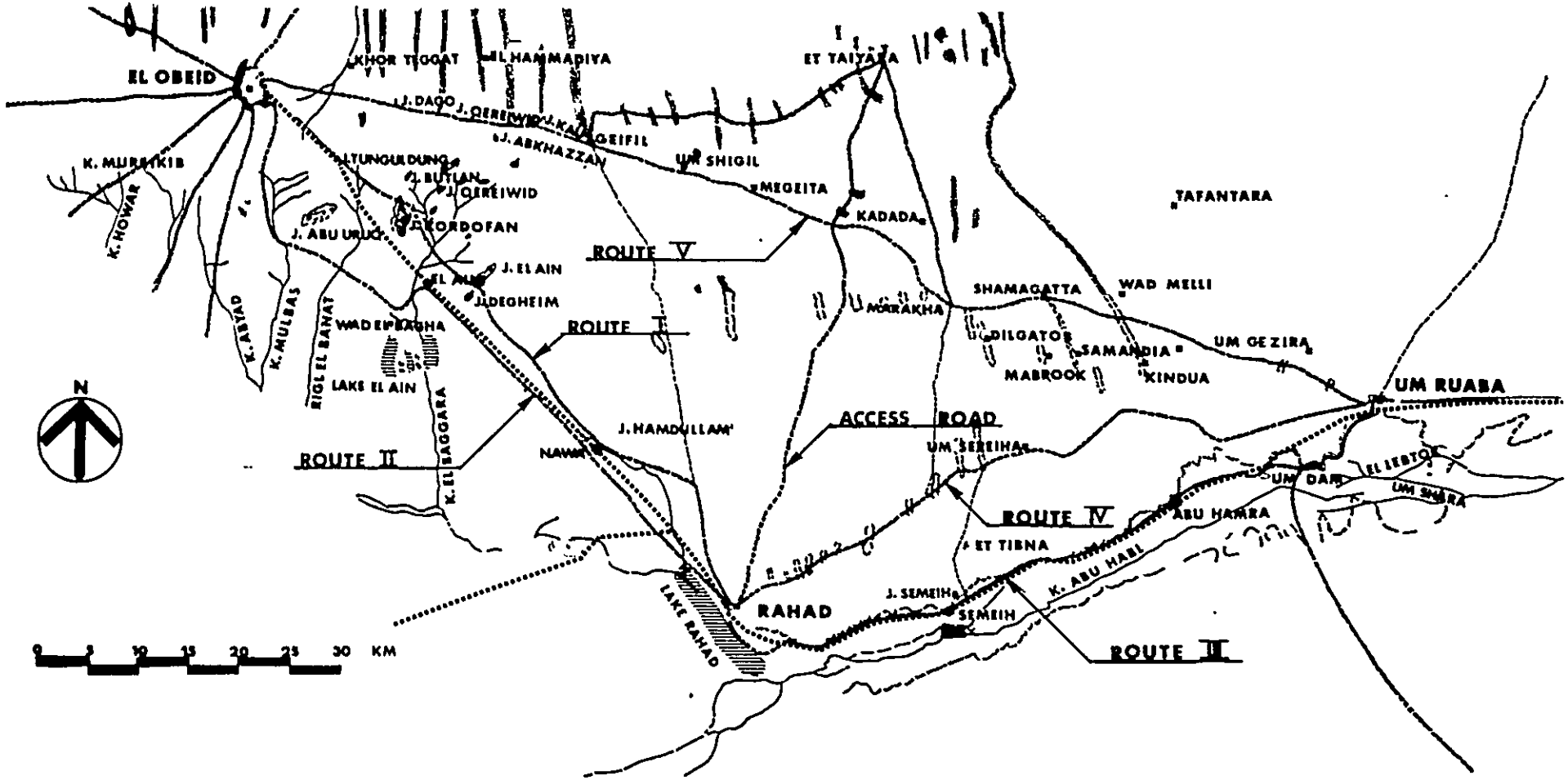
The construction work commenced in November, 1972 and was completed in July, 1977. This increases the total maximum capacity of all reservoirs to 5.5 million m^3. The last stage of the project, the construction of a dam for 0.5 million m^3 capacity reservior, started in January, 1977, will cost LS 0.20 million. That computes to LS 0.40 per the capacity of m^3.

It is expected that after completion the reserviors will supply sufficient water for the people in El Obeid with some remaining for other uses, especially for agriculture.

ANNEX V

FIG. 5-1 EXISTING ROADS

ANNEX V-1



LEGEND

EXISTING ROADS

RAILWAYS

RIVERS (KHORS)

QOZ

HILLS

TABLE 5-1 GRADIENT CONDITION OF EXISTING ROADS

(km)

Route	Surface	Distance by Gradient			Total	Remarks
		i = 0-3%	i = 3-5%	i = 5%-		
I	Pavement	2.2	0	0		
	Earth 1)	1.4	0	0		
	Track 2)	67.8	3.8	0		
	Total	71.4	3.8	0	75.2	
II	Pavement	2.2	0	0		
	Earth	24.1	0	0		
	Track	48.2	1.1	0.2		
	Total	74.5	1.1	0.2	75.8	
III	Pavement	0	0	0		
	Earth	2.5	0	0		
	Track	76.5	0	0		
	Total	79.0	0	0	79.0	
IV	Pavement	0	0	0		
	Earth	3.9	0	0		
	Track	41.8	17.1	9.7		
	Total	45.7	17.1	9.7	72.5	
V	Pavement	0	0	0		
	Earth	3.7	0	0		
	Track	81.5	22.1	11.4		
	Total	85.2	22.1	11.4	118.7	
Access Road	Pavement	0	0	0		
	Earth	1.6	0	0		
	Track	38.3	1.0	0		
	Total	39.9	1.0	0	40.9	

Notes: 1) Sections having either hard surface or some engineering works.
2) Sections having no engineering work.

TABLE 5-2 SURFACE CONDITION OF EXISTING ROADS

(km)

Route	Length by Surface Condition							Total
	Pavement	Earth [1]			Track [2]			
	Poor	Fair	Poor	Bad	Fair	Poor	Bad	
I	2.2	0	1.0	0.4	29.5	20.1	22.0	75.2
II	2.2	14.6	6.6	2.9	9.2	21.0	19.3	75.8
III	0	0	1.1	1.4	16.3	23.3	36.9	79.0
IV	0	0	1.1	2.8	0	6.6	62.0	72.5
V	0	1.0	2.7	0	2.3	27.8	84.9	118.7
Access Road	0	0	1.6	0	0	10.3	29.0	40.9

Notes: 1) Sections having either hard surface or some engineering works.

2) Sections having no engineering work.

TABLE 5-3-1 INVENTORY OF THE EXISTING ROAD

ANNEX V-4

Route I El Obeid ——— Rahad (75.2km) (km)

Gradient	Surface Condition		Soil Condition					Sub Total	Total
			Qoz	Sandy Silt	Silty Clay	Cotton Clay	Clay		
0% < i < 3%	Pavement	Poor	Bituminous 2.2					2.2	
	Earth	Poor	1.0						
		Bad	0.4					1.4	
	Track	Fair		20.1	*5.9 2.6				
		Poor	3.8	8.3	6.7				
		Bad	9.1	4.0	7.3			67.8	71.4
3% ≦ i < 5%	Track	Fair	0.5		0.4				
		Poor	1.3						
		Bad	1.4		0.2			3.8	

* Hard surface

TABLE 5-3-2 INVENTORY OF THE EXISTING ROAD

ANNEX V-4

Route II El Obeid ——— Rahad (75.8km) (km)

Gradient	Surface Condition		Soil Condition					Sub Total	Total
			Qoz	Sandy Silt	Silty Clay	Cotton Clay	Clay		
0% < i < 3%	Pavement	Poor	Bituminous 2.2					2.2	
	Earth	Fair		6.4	8.2				
		Poor	0.2	1.4	5.0				
		Bad		0.6	2.3			24.1	
	Track	Fair		3.1	6.1				
		Poor	1.6	10.3	8.4				
		Bad	6.7	5.7	6.3			48.2	74.5
3 ≦ i < 5%	Track	Poor	0.3	0.4					
		Bad	0.2	0.2				1.1	1.1
5% ≦ i	Track	Bad		0.2				0.2	0.2

TABLE 5-3-3 INVENTORY OF THE EXISTING ROAD

ANNEX V-4

Route III Rahad ____ Um Ruaba (79.0km) (km)

Gradient	Surface Condition		Soil Condition					Sub Total	Total
			Qoz	Sandy Silt	Silty Clay	Cotton Clay	Clay		
0% < i < 3%	Earth	Poor	1.1						
		Bad	1.4					2.5	
	Track	Fair				16.3			
		Poor	4.1			19.2			
		Bad	8.1			28.8		76.5	79.0

TABLE 5-3-4 INVENTORY OF THE EXISTING ROAD

ANNEX V-4

Route IV Rahad ____ Um Ruaba (72.5km) (km)

Gradient	Surface Condition		Soil Condition					Sub Total	Total
			Qoz	Sandy Silt	Silty Clay	Cotton Clay	Clay		
0% < i < 3%	Earth	Poor	1.1						
		Bad	2.8					3.9	
	Track	Poor	6.4						
		Bad	34.2				1.2	41.8	45.7
3% ≦ i < 5%	Track	Poor	0.2						
		Bad	15.9				1.0	17.1	17.1
i ≧ 5%	Track	Bad	9.7					9.7	9.7

TABLE 5-3-5 INVENTORY OF THE EXISTING ROAD

ANNEX V-4

Route V El Obeid —— Um Ruaba (118.7km) (km)

Gradient	Surface Condition		Soil Condition					Sub Total	Total
			Qoz	sandy silt	silty clay	cotton clay	Clay		
0%<i<3%	Earth	Fair		1.0					
		Poor	0.7	2.0				3.7	
	Track	Fair		2.3					
		Poor	7.5	15.9	2.3				
		Bad	42.0	4.9	4.6		2.0	81.5	85.2
3%≦i<5%	Track	Poor		2.1					
		Bad	15.1	2.9	2.0			22.1	22.1
5%≦i	Track	Bad	11.4					11.4	11.4

TABLE 5-3-6 INVENTORY OF THE EIXSTING ROAD

ANNEX V-4

Access Road Rahad —— Route V (40.9km) (km)

Gradient	Surface Condition		Soil Condition					Sub Total	Total
			Qoz	Sandy Silt	Silty Clay	Cotton Clay	Clay		
0%<i<3%	Earth	Poor	1.6					1.6	
	Track	Poor	8.0	2.3					
		Bad	23.7	4.3				38.3	39.9
3%≦i<5%	Track	Bad	1.0					1.0	1.0

FIG. 5-2 SOIL MAP OF PROJECT AREA

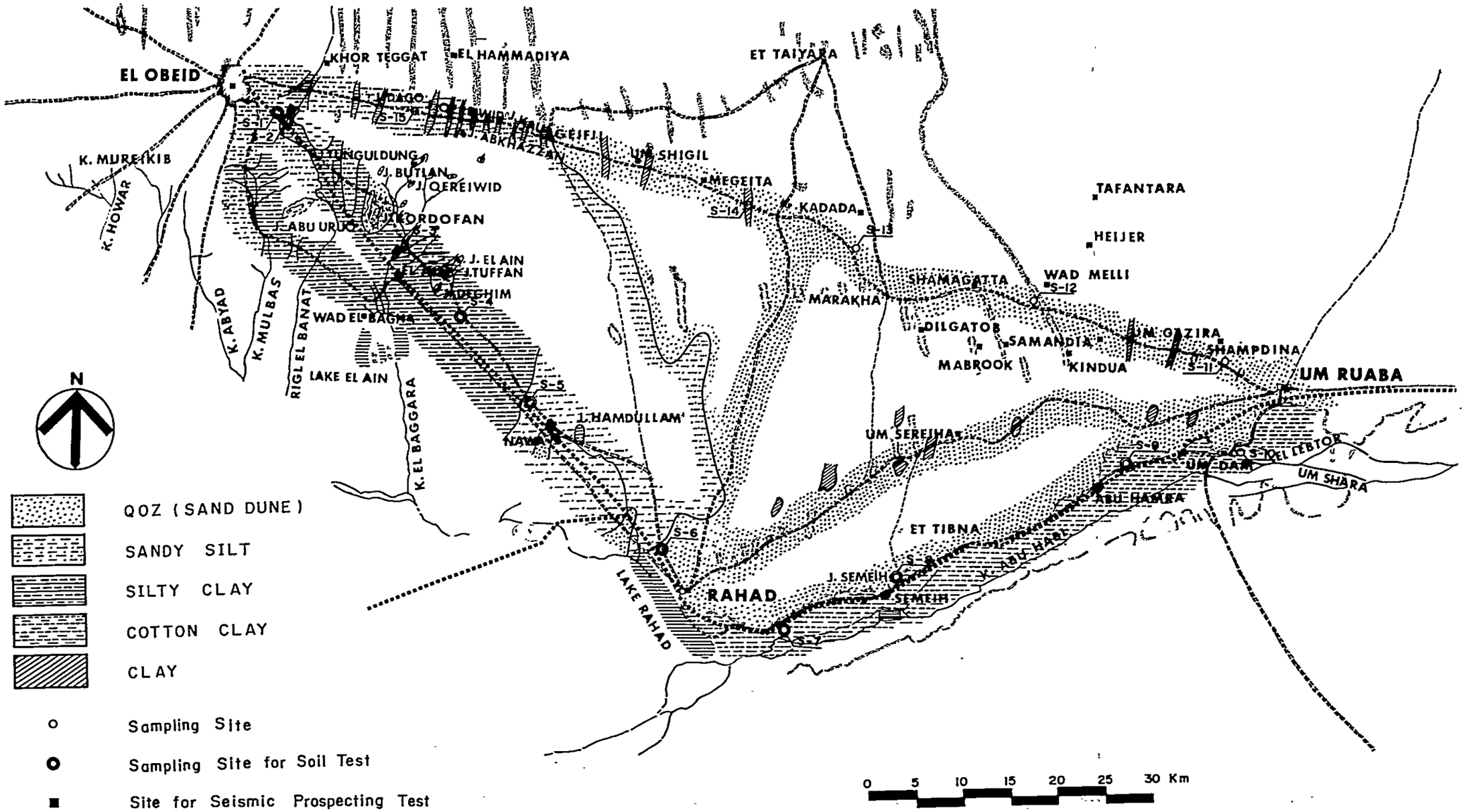


TABLE 5-4 SUMMARY OF SOIL TESTS

Sample No.		S-6	S-8	S-1	S-5	S-2	S-4	S-7	S-10
Soil Type		QOZ (sand dune)	QOZ (sand dune)	Sandy Silt	Sandy Slit	Brown Silty Clay	Yellow Grey Silty Clay	Cotton Clay	Cotton Clay
Specific Gravity		2.59	2.60	2.58	2.45	2.68	2.68	2.64	2.70
Particle Size Analysis	Sand %	87.9	96.5	78.4	71.4	59.5	51.8	61.1	1.4
	Silt and Clay %	12.1	3.5	21.6	28.6	40.5	48.2	38.9	98.6
Atterberg Limit	Liquid Limit %	- 1)	-	-	17.0	38.3	24.9	28.5	63.4
	Plastic Limit %	N.P.	N.P.	N.P.	N.P.	18.7	13.7	12.2	32.8
	Plasticity Index	N.P.	N.P.	N.P.	N.P.	19.6	11.2	16.3	30.6
Shrinkage Limit %		-	-	-	-	-	-	23.25	23.56
Classification	AASHTO 3)	A-3 (0)	A-3-(0)	A-2-4 (0)	A-2-4 (0)	A-6(4)	A-6 (3)	A-6 (2)	A-7-6 (13)
	Casagrande 2)	SU	SU	SC	SC	CI	CL	CL	OH
Compaction	OMC %	9.4	11.2	7.4	6.4	11.2	9.4	11.2	19.0
	MDD t/m^3	1.93	1.76	2.06	2.07	2.02	2.06	1.97	1.71
CBR Modified %		18.6	13.2	18.0	12.4	9.2	5.6	2.2	3.2
Adopted CBR for Pavement Design %		12	12	12	12	9	5	3	3

Notes: 1) Non plastic.
2) SU: uniform sands with little or no fines. SC: well graded sands with small clay content. CI: clays (inorganic) of medium plasticity. CL: clay silts (inorganic). OH: organic clays of high plasticity.
3) Classification is based on the following table.

CLASSIFICATION OF SOILS AND SOIL-AGGREGATE MIXTURES

Group Classification	A-3	A-2-4	A-6	A-7-6
Sieve Analysis Percent Passing:				
2.00 mm (No. 10)	-	-	-	-
0.425 mm (No. 40)	51 min.	-	-	-
0.075 mm (No. 200)	10 max.	35 max.	36 min.	36 min.
Characteristics of Fraction Passing 0.425 mm (No. 40)				
Liquid limit	-	40 max.	40 max.	41 min.
Plasticity Index	N.P.	10 max.	11 min.	11 min.
General Rating as Sub-grade	Excellent to Good		Fair to Poor	

Note: A figure in ( ) means group index as calculated by AASHTO specification.

Source: AASHTO Designation: M145-73.

ANNEX V-7 BEARING CAPACITY OF BRIDGE FOUNDATION GROUND

7.1 Elastic Wave Velocity of Foundation Ground

The results of the seismic prospecting test indicate that P-wave velocity (Vp)[1] is 800 to 900 m/sec as shown in FIG.5-3-1, 2 & 3, which means the foundation ground is rather firmly compacted. An experimental relationship between P-wave velocity (Vp) and S-wave velocity is shown in FIG.5-3-4 by using Poisson's Ratio (σ)[2] as a parameter. Applying this relationship with an assumption $\sigma = 0.47$, the S-wave velocity (Vs)[1] of the foundation ground is estimated between 230 m/sec to 250 m/sec.

An experiment conducted in the consultants' laboratory showed that (Vp) was 926 m/sec and (Vs) was 320 m/sec. Poisson's Ratio (σ) is estimated by the following formula and the result shows that $\sigma = 0.43$.

$$Vs = \frac{Vp}{\sqrt{\frac{1-\sigma}{1/2-\sigma}}}$$

7.2 N Values of Foundation Ground

There are a number of report and article which presents a relationship between N values and values of Vs. FIG. 5-3-5 is an example.

N_1 values are estimated by applying the data on FIG. 5-3-5, Annex V-7 and N_2 values are estimated by the formula bellow [3].

Vs (m/sec)	230	250	320
N_1 [2]	22	23	46
N_2 [3]	15	22	45

7.3 Bearing Capacity of Foundation Ground

The allowable bearing capacity (Q) based on the above values of N is estimated by the following formula, which Dunham proposed.

$$Q = 1.17\ N\ (t/m^2)$$

(Note: In case the soil is diluvium silty clay)

With these studies, it is considered reasonable to assume the foundation ground has an allowable bearing capacity in terms of Q value at more than 25 t/m^2.

Notes: 1) J.T. Cherry and K.H. Waters, "Shear-wave Recording Using Continuous Signal Methods, Part I - Early Development" Geophisics, Vol. 33, No. 2 (U.S.A., 1968).
" A shear (S) wave is defined as a disturbance which moves through an infinite medium in such a manner that the displacement of a point is parallel to the wavefront, in distinction to a compressional (P) wave in which the displacement of a point is perpendicular to the wavefront. The speeds of the two types of wave are different and are controlled by the density and two different elastic moduli of the medium. The P-wave velocity is always higher than the S-wave velocity($0 < Vs \leq 0.7Vp$), and the ratio between the velocities (Vs/Vp) represents a dynamic measurement of an elastic property of the medium; from it, if desired, one can derive a particular elastic constant of the medium called Poisson's ratio."

2) T. Imai and M. Yoshimura, "The Relation of Mechanical Properties of Soils to P and S Wave Velocities", Geophisical Exploration, VOL. XXV, No. 6 (Tokyo, The Society of Exploration Geophysicists of Japan, 1972).

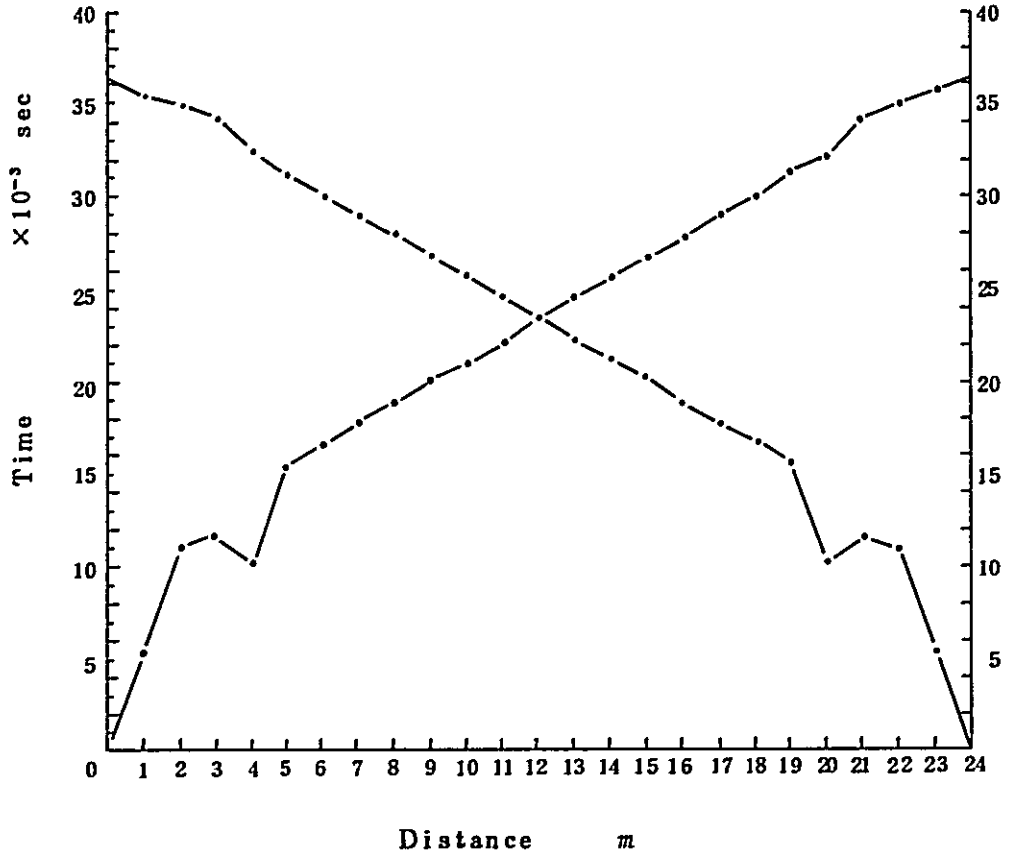
3) Y. Ohta and N. Goto, "Estimation of S-Wave Velocity in Terms of Characteristics Indices of Soil", Geophisical Exploration, VOL. XXIX, No. 4 (Ibid, 1976).

$$Vs = 85.34\ N^{0.348}\ (r = 0.719)$$

FIG. 5-3-1 Analysis of Seismic Prospecting

7.4 km from EL OBEID

Time - Distance Curve



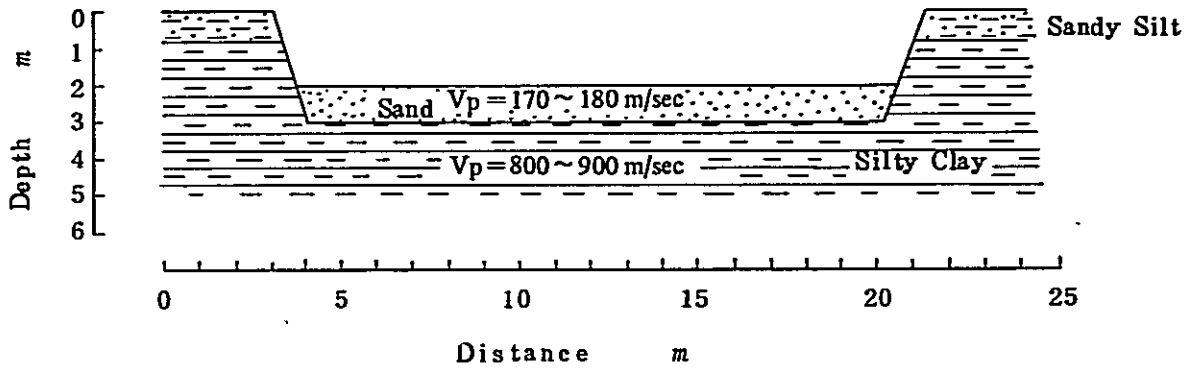


FIG. 5-3-2 Analysis of Seismic Prospecting
(K. EL BAGGARA)

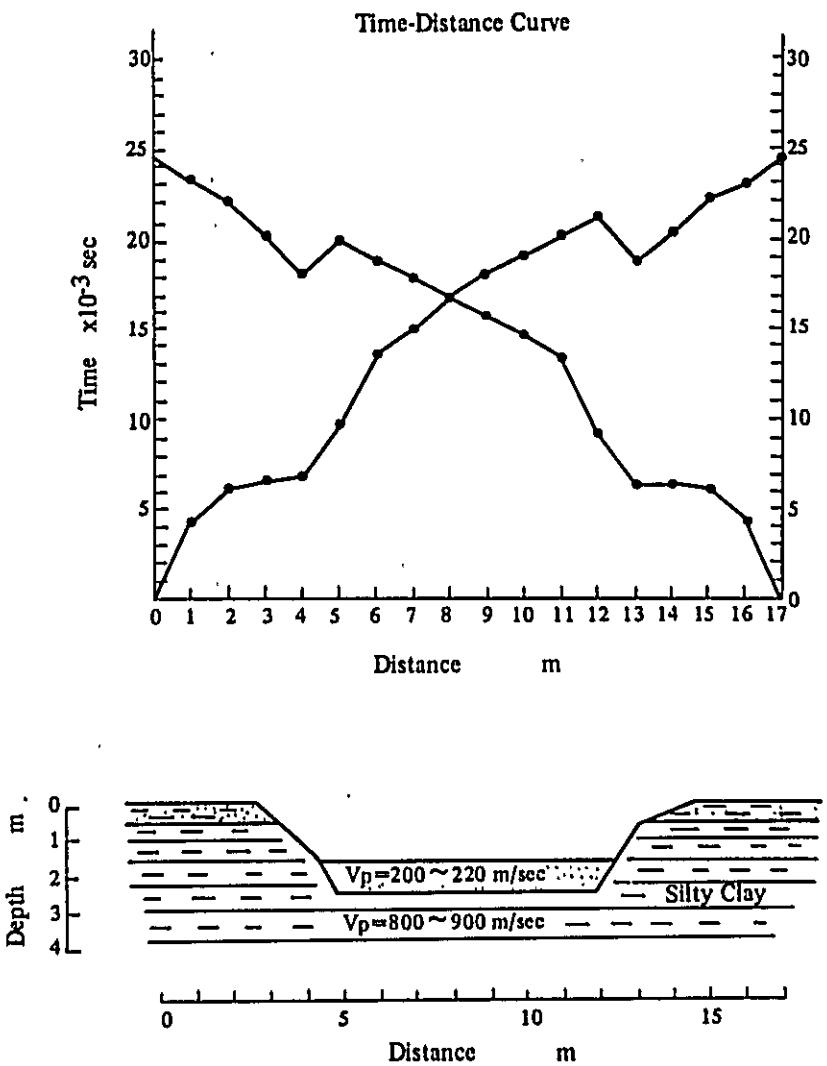


FIG. 5-3-3 Analysis of Seismic Prospecting
(K. NAWA)

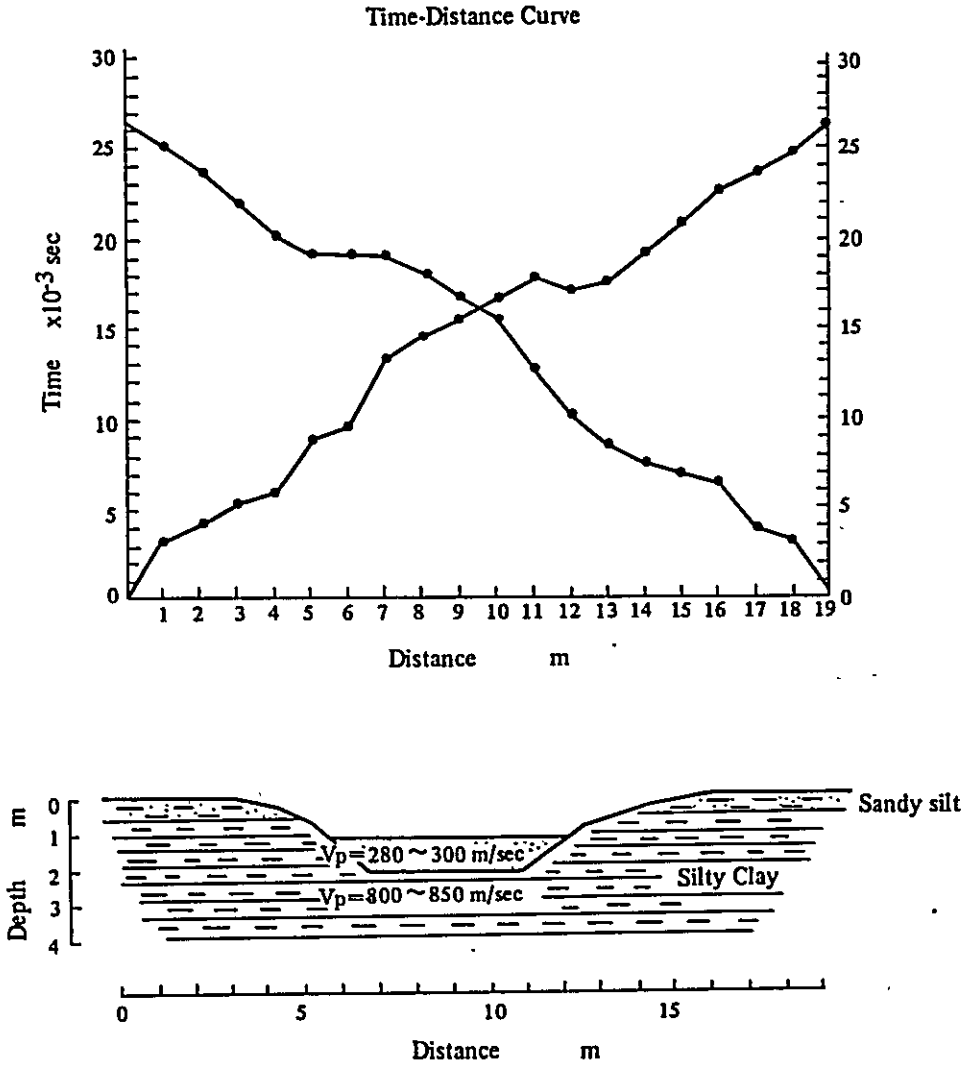
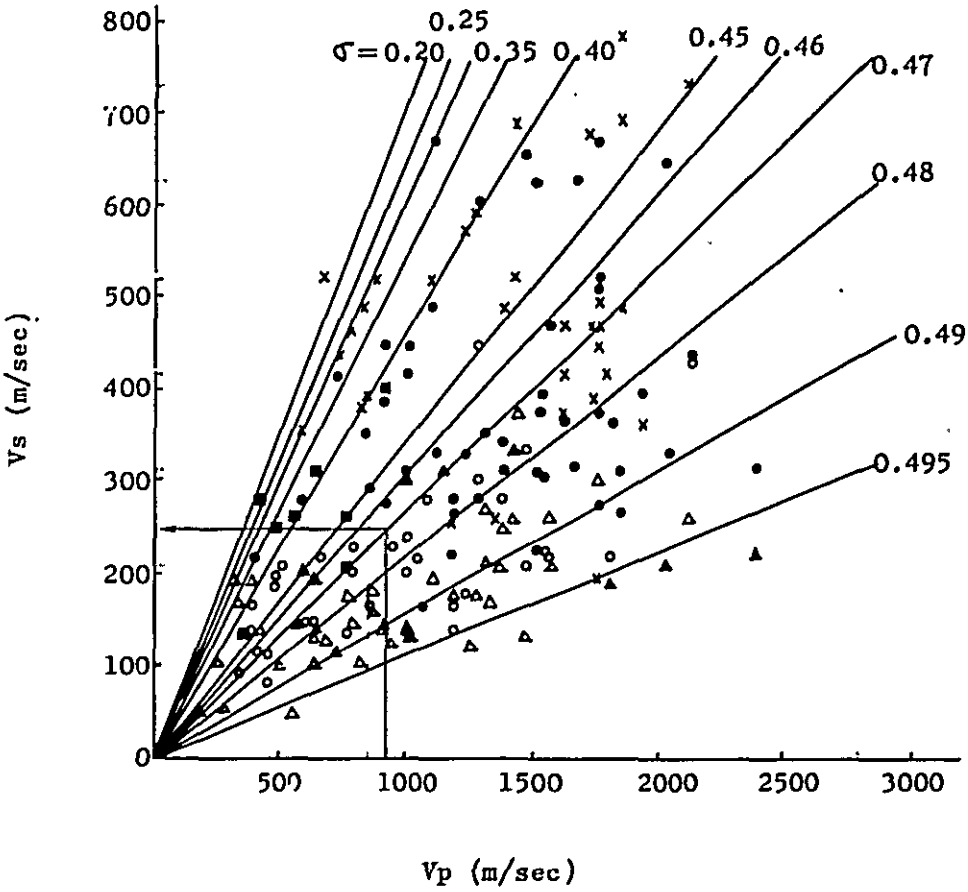


FIG. 5-3-4 S Wave Velocity —— P Wave Velocity



σ Poisson's Ratio

FIG. 5-3-5 N Value —— S Wave Velocity

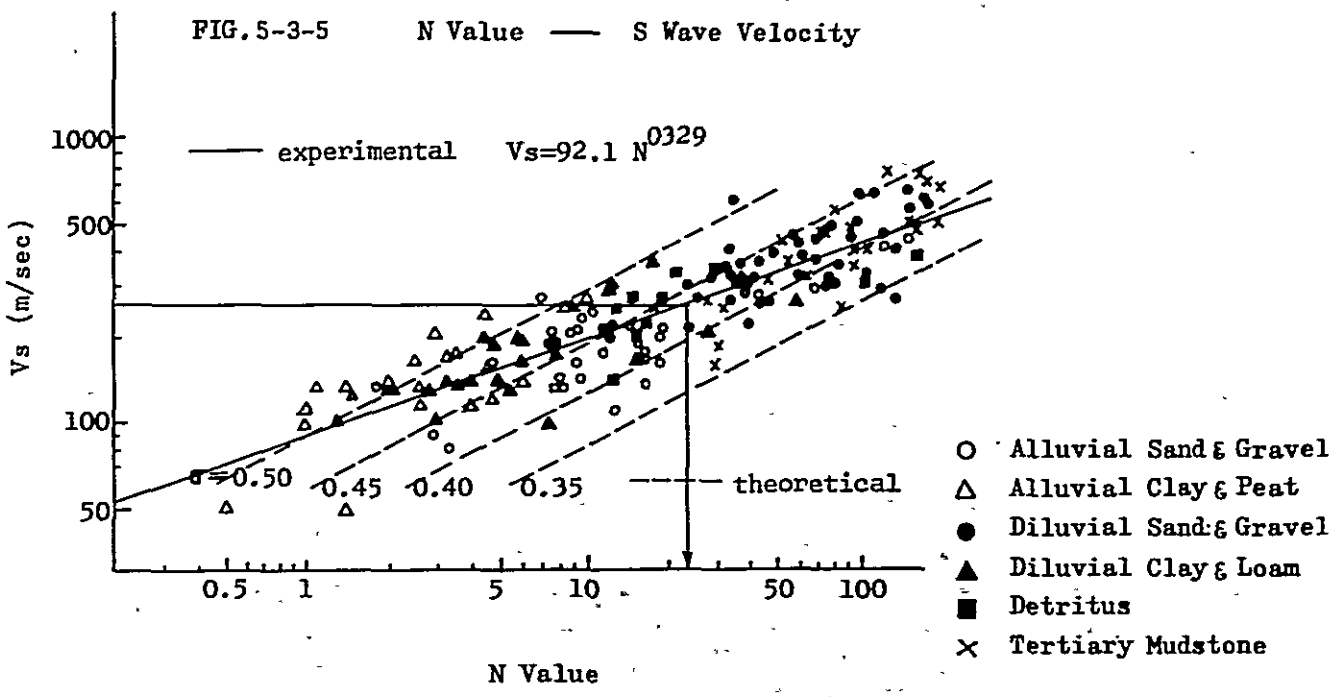
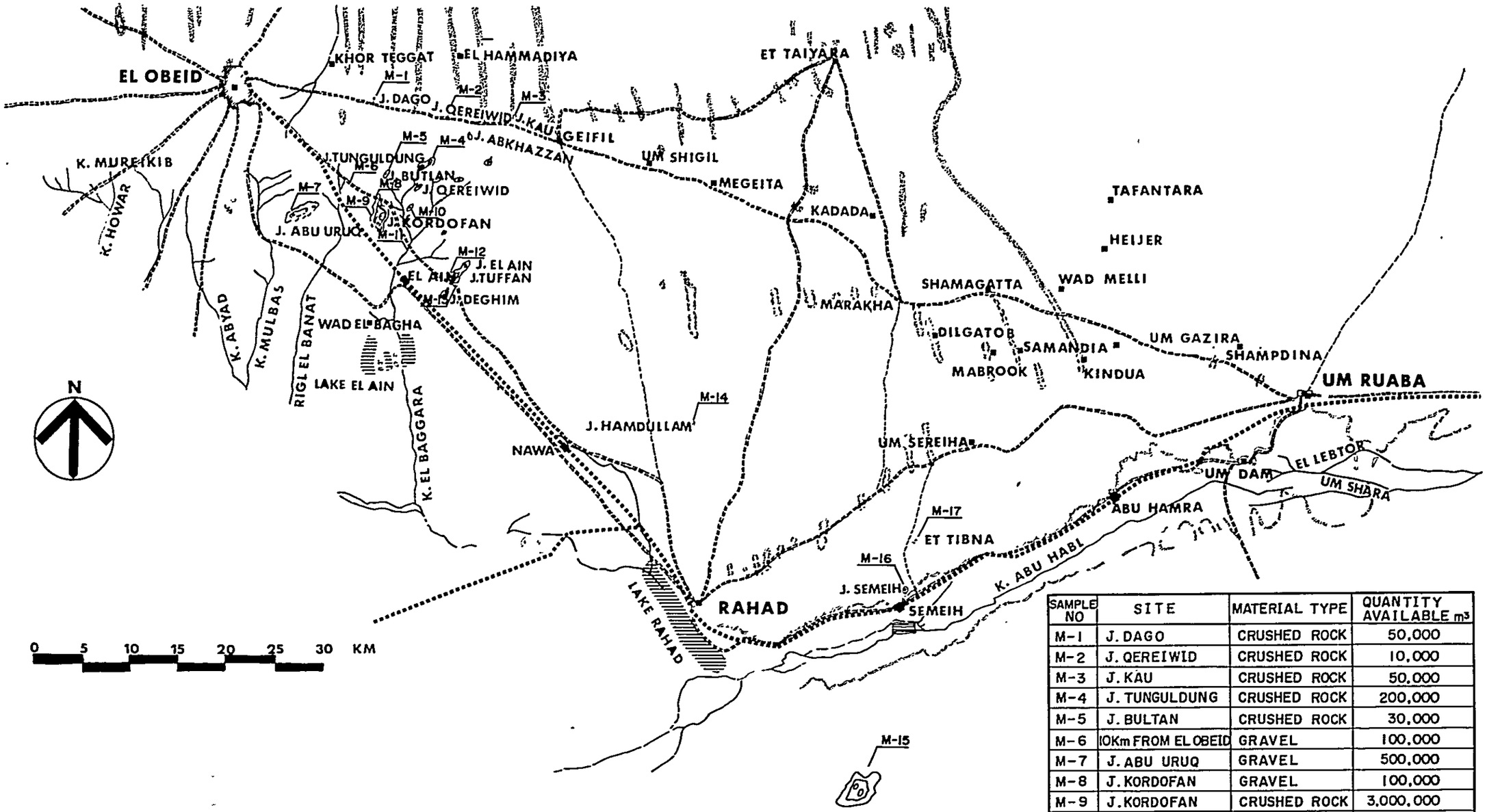


FIG. 5-3-6 LOCATION MAP OF MATERIALS



SAMPLE NO	SITE	MATERIAL TYPE	QUANTITY AVAILABLE m³
M-1	J. DAGO	CRUSHED ROCK	50,000
M-2	J. QEREIWID	CRUSHED ROCK	10,000
M-3	J. KAU	CRUSHED ROCK	50,000
M-4	J. TUNGULDUNG	CRUSHED ROCK	200,000
M-5	J. BULTAN	CRUSHED ROCK	30,000
M-6	10Km FROM EL OBEID	GRAVEL	100,000
M-7	J. ABU URUQ	GRAVEL	500,000
M-8	J. KORDOFAN	GRAVEL	100,000
M-9	J. KORDOFAN	CRUSHED ROCK	3,000,000
M-10	J. QEREIWID	CRUSHED ROCK	20,000
M-11	K. EL BAGGARA	COARSE SAND	100,000
M-12	J. TUFFAN	CRUSHED ROCK	200,000
M-13	J. TUFFAN	GRAVEL	10,000
M-14	J. HAMDULLAM	CRUSHED ROCK	150,000
M-15	J. DUMBEIR	CRUSHED ROCK	4,000,000
M-16	J. SEMEIH	CRUSHED ROCK	20,000
M-17	J. ET TIBNA	GRAVEL	10,000

TABLE 5-5 SUMMARY OF MATERIAL TESTS

Crushed Rock and Sand

Sample No.	Site	Specific Gravity	Absorption %	Los Angeles Abrasion %	Suitability for Surface Course	Suitability for Concrete Aggregate
M-1	J. DAGO	2.63	0.6	26.2	GOOD	GOOD
M-9	J. KORDOFAN	2.61	0.9	37.9	GOOD	GOOD
M-10	J. QEREIWID	2.62	1.4	44.7	POOR	POOR
M-12	J. TUFFAN	2.56	1.4	50.3	POOR	POOR
M-14	J. HAMDULLAH	2.53	3.0	14.1	GOOD	GOOD
M-16	J. SEMEIH	2.88	0.8	18.3	GOOD	GOOD
M-11	K. EL BAGGARA	2.62	0.6	-	POOR	GOOD

Gravel

Sample No.	Site	Specific Gravity	Absorption %	Los Angeles Abrasion %	C B R Modified %	Suitability for Subbase Course	Suitability for Base Course
M-7	J. ABU URUQ	-	-	-	88 [1)]	GOOD	GOOD
M-6	10 km from EL OBEID	2.62	0.75	23.4	28.3	FAIR	POOR
M-8	J. KORDOFAN	2.65	0.38	33.2	14.2	POOR	POOR
M-13	J. TUFFAN	2.55	0.69	35.4	33.3	GOOD	POOR
M-17	J. ETTIBNA	2.61	0.70	31.9	40.8	GOOD	POOR

Note: 1) The test result carried out for EL OBEID Airport Construction by R B.P C.'s laboratory.

General Rating as Aggregate

Item		Subbase Course GOOD[1)]	Subbase Course FAIR[1)]	Subbase Course POOR[2)]	Base Course GOOD[1)]	Base Course POOR[2)]	Surface Course GOOD[1)]	Surface Course POOR[2)]	Concrete Aggregate GOOD[1)]	Concrete Aggregate POOR[2)]
Absorption	%	<3		≧3	<3	≧3	<3	≧3	<3	≧3
Los Angeles Abrasion	%	<50		≧50	<50	≧50	<40	≧40	<40	≧40
C.B.R. Modified	%	>30	25-30	<25	≧80	<80	-	-	-	-

Notes: 1) The rating as "GOOD" or "FAIR" should meet the three conditions listed in each column.

2) The rating as "POOR" comes when one condition in each column is satisfied.

TABLE 5-6 RESULT OF CEMENT STABILIZATION TEST

Cement Contents %		2	4	6	8	10
Unconfined Compression Strength Kg/cm^2		4.2	4.9	10.8	23.7	25.4
C B R Value %		-	203	254	266	312
Compaction Test	OMC %	12.2	11.3	11.0	10.5	10.2
	γ_{dmax} g/cm^3	1.75	1.77	1.81	1.83	1.85

Note : When the cement is added at 6 % or more, cracking is likely to occur while other test results are acceptable. When the cement is added at 5 % or less, cracking will not occur while other test figures are not acceptable. It is concluded the cement stabilization is not included in the engineering plan.

TABLE 5-7 RESULT OF LIME STABILIZATION TEST

Lime Contents %		5	10	15
Unconfined Compression Strength Kg/cm^2	Medium curing	-	0.4	0.6
	Rapid curing	-	2.8	2.8
Compaction Test	OMC %	11.0	10.5	10.0
	γ_{dmax} g/cm^3	1.80	1.87	1.94

TABLE 5-8 RESULT OF ASPHALT STABILIZATION TEST
(Hubbard-Field Stability)

Asphalt Contents %	6	7	8	9	10
Air Void %	25.3	23.3	21.8	16.4	15.3
Hubbard-Field Stability Kg	220	200	300	30	30

TABLE 5-9 RESULT OF ASPHALT STABILIZATION TEST
(Marshall Stability)

Asphalt Contents %	7	8	9
Air Void %	21.2	18.0	18.1
Marshall Stability Kg	35	40	20

Fig. 5-4 Cement Content ~ Unconfined Compression Strength

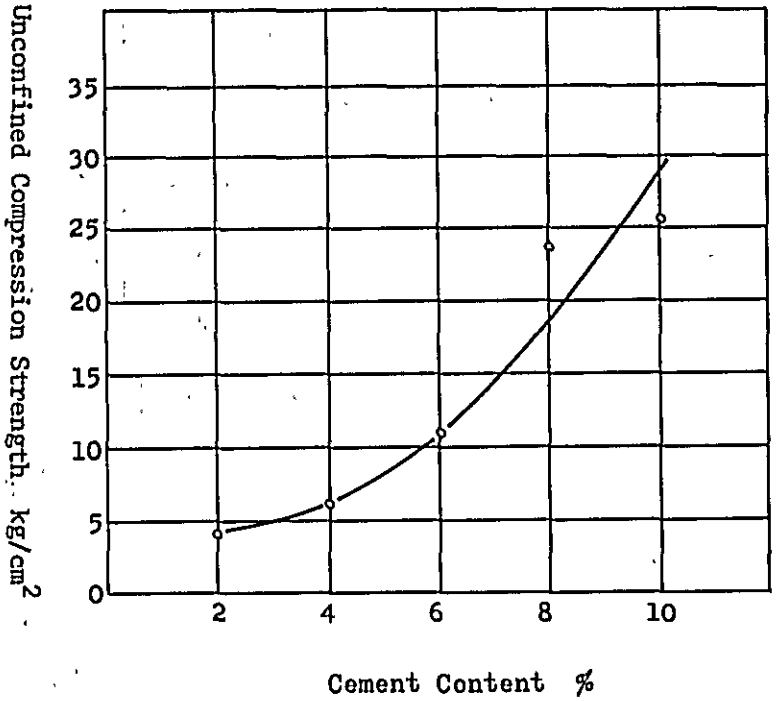


Fig. 5-5 Wetting-And-Drying Test (Soil Cement Loss)

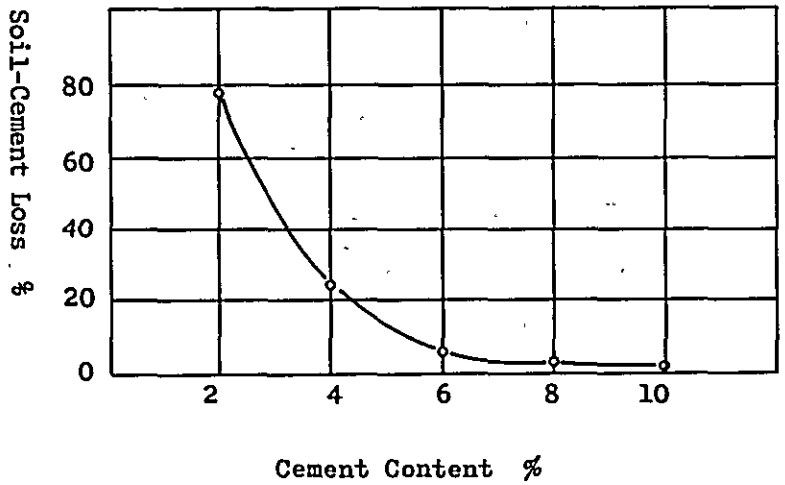
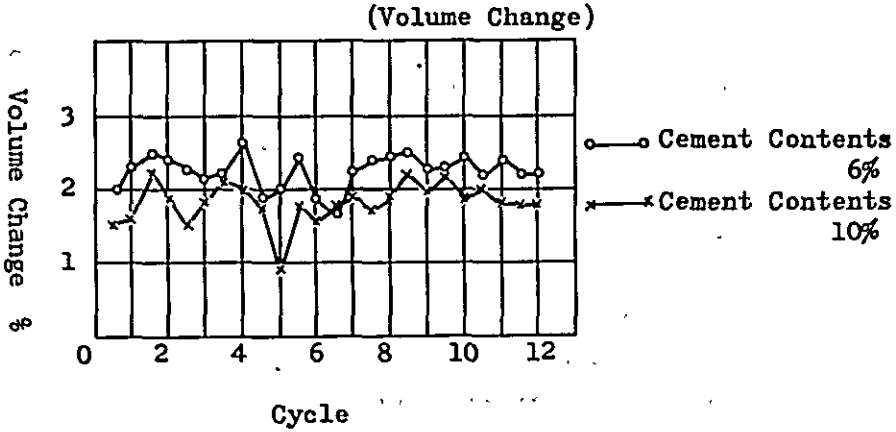


Fig. 5-6 Wetting-And-Drying Test (Volume Change)



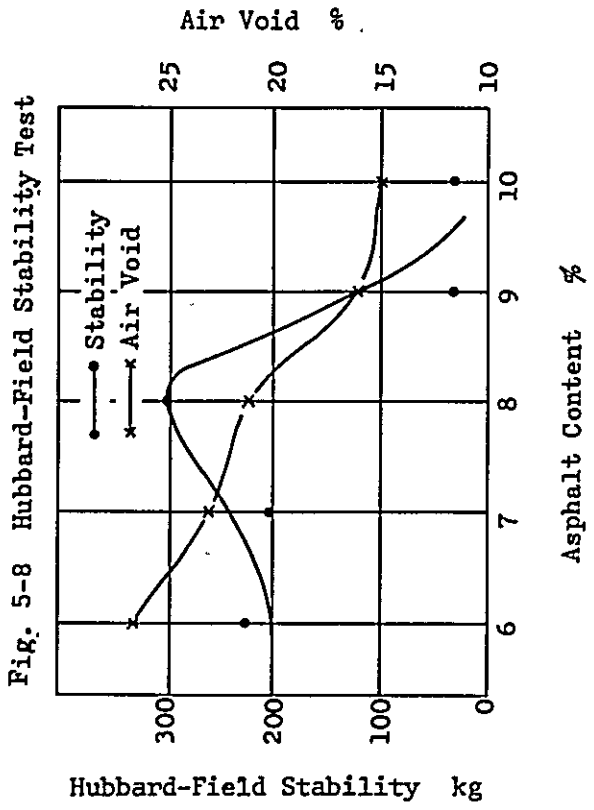


Fig. 5-8 Hubbard-Field Stability Test

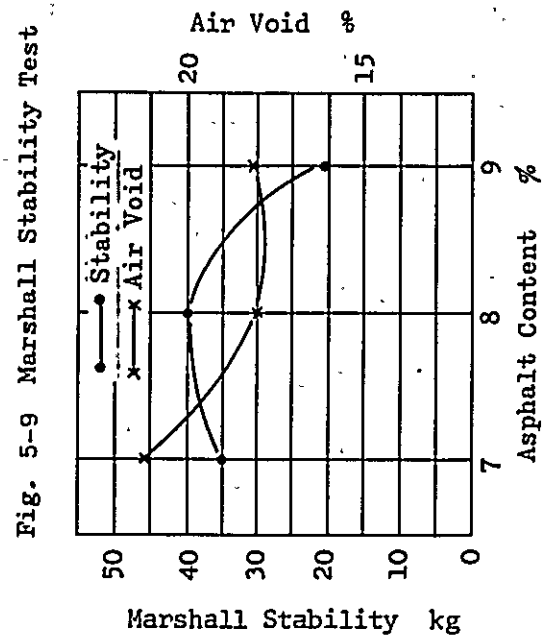


Fig. 5-9 Marshall Stability Test

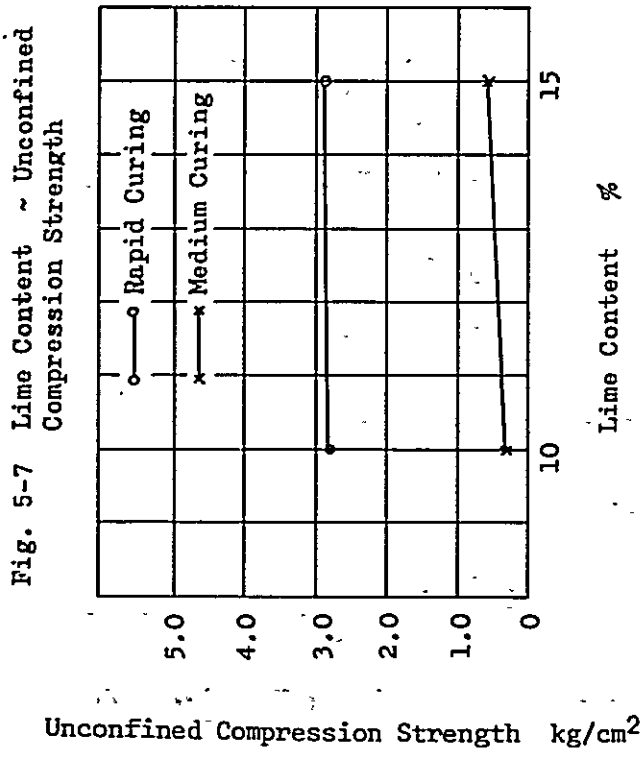
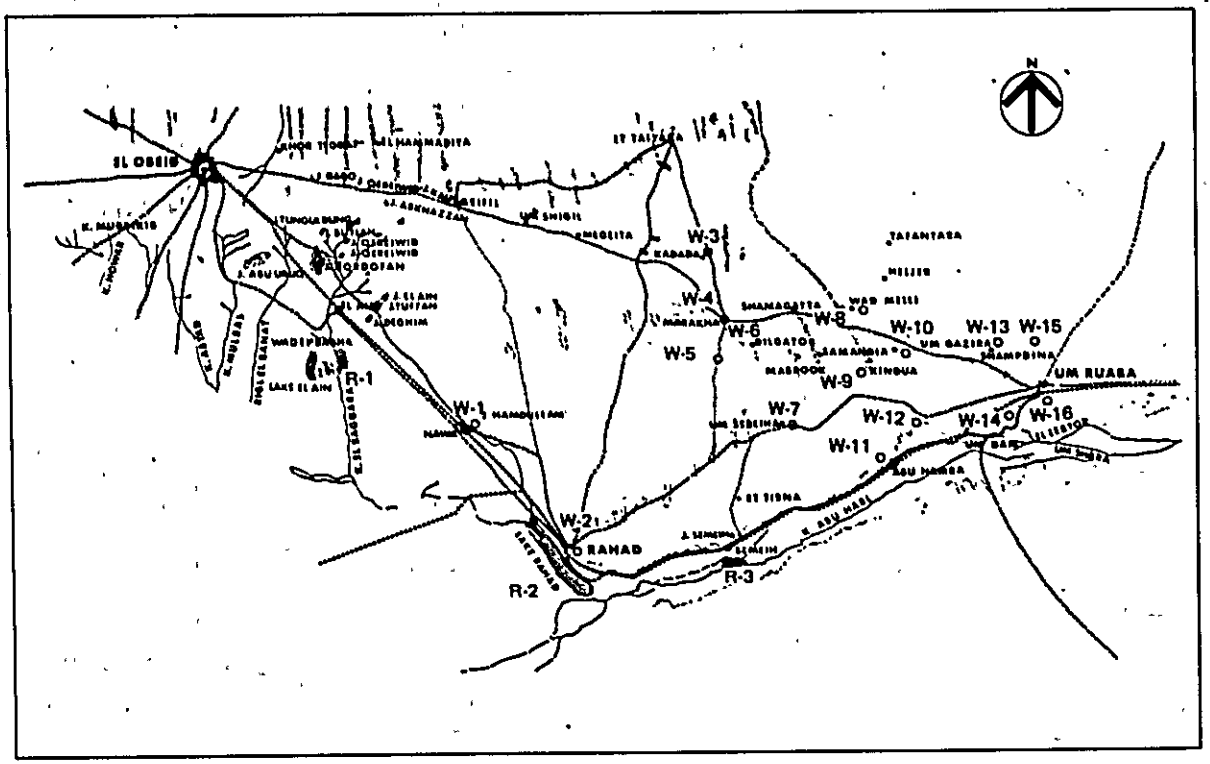


Fig. 5-7 Lime Content ~ Unconfined Compression Strength

ANNEX V-13

Fig. 5-10 Location Map of Reservoirs and Wells



Wells

NO.	LOCATION	NO. OF WELLS	YIELD ℓ/h	GROUND WATER LEVEL
W-1	NAVA	2	5450, 4360	5 - 10 m
W-2	RAHAD	3	5450, 4360, 2270	
W-3	KADADA	2	5450, 4090	80 - 90 m
W-4	MARAKHA	2	4670, 4670	
W-5	ABU SAD	1		
W-6	DILGATOB	2	5680, 1820	
W-7	UM SERKINA	2	2550, 2950	
W-8	WAD MELLI	1	9090	
W-9	KINDUA	1	3180	
W-10	HAMANDIA	2	5460, 5460	
W-11	ABU HAMRA	3	3180, 4360, 4360	
W-12	KUAKAMCHA	2	1180, 2270	
W-13	UM GEZIRA	2	4180, 4180	
W-14	GADADIM	1	13640	
W-15	UM GENNAS	2	2270, 2270	
W-16	UM RUABA	12	4360 - 13640	

Reservoirs m^3

NO.	LOCATION	CAPACITY
R-1	AL AIN	5,500,000
R-2	RAHAD	56,000,000
R-3	SEMEIH	120,000

FIG. 5 - 11 AVERAGE ANNUAL RAINFALL , 1921 - 1950

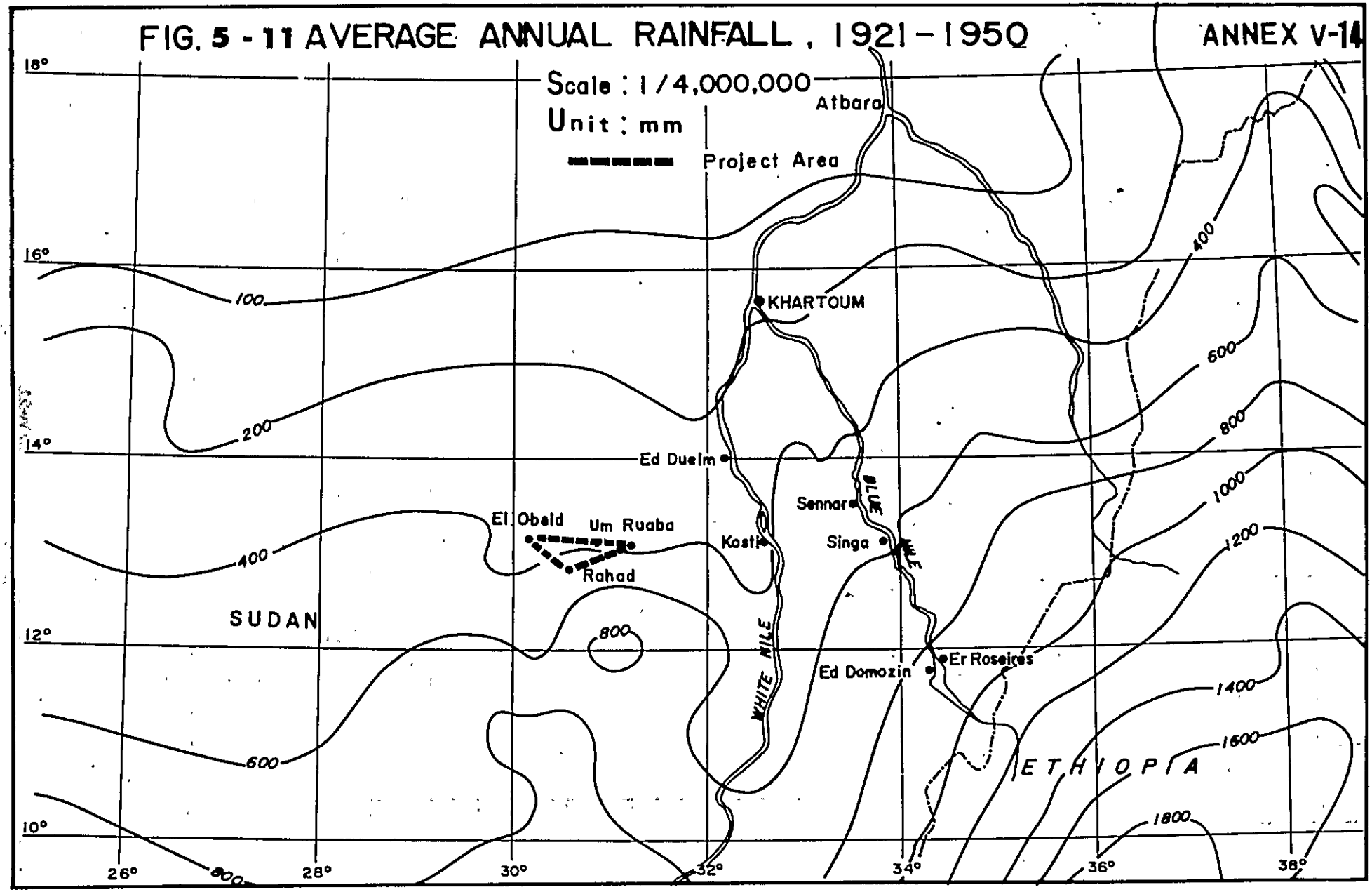


TABLE 5-10 ANNUAL MAXIMUM DAILY RAINFALL, EL OBEID, 1943 - 1976

Year	Daily Rainfall (mm/Day)	Year	Daily Rainfall (mm/Day)	Year	Daily Rainfall (mm/Day)
1943	44.2	1954	75.0	1965	48.0
44	53.5	55	56.2	66	53.2
45	81.2	56	96.7	67	54.7
46	96.7	57	26.7	68	45.6
47	44.7	58	56.0	69	19.4
48	50.7	59	78.1	70	36.2
49	35.6	60	54.2	71	-
50	40.6	61	50.9	72	-
51	69.1	62	73.6	73	-
52	68.2	63	34.1	74	40.7
53	56.2	64	57.3	75	34.2
				76	67.5

Source: Meteorological Department, Sudan

FIG. 5-12 PROBABILITY OF DAILY RAINFALL (GUMBEL METHOD)

ANNEX V-16

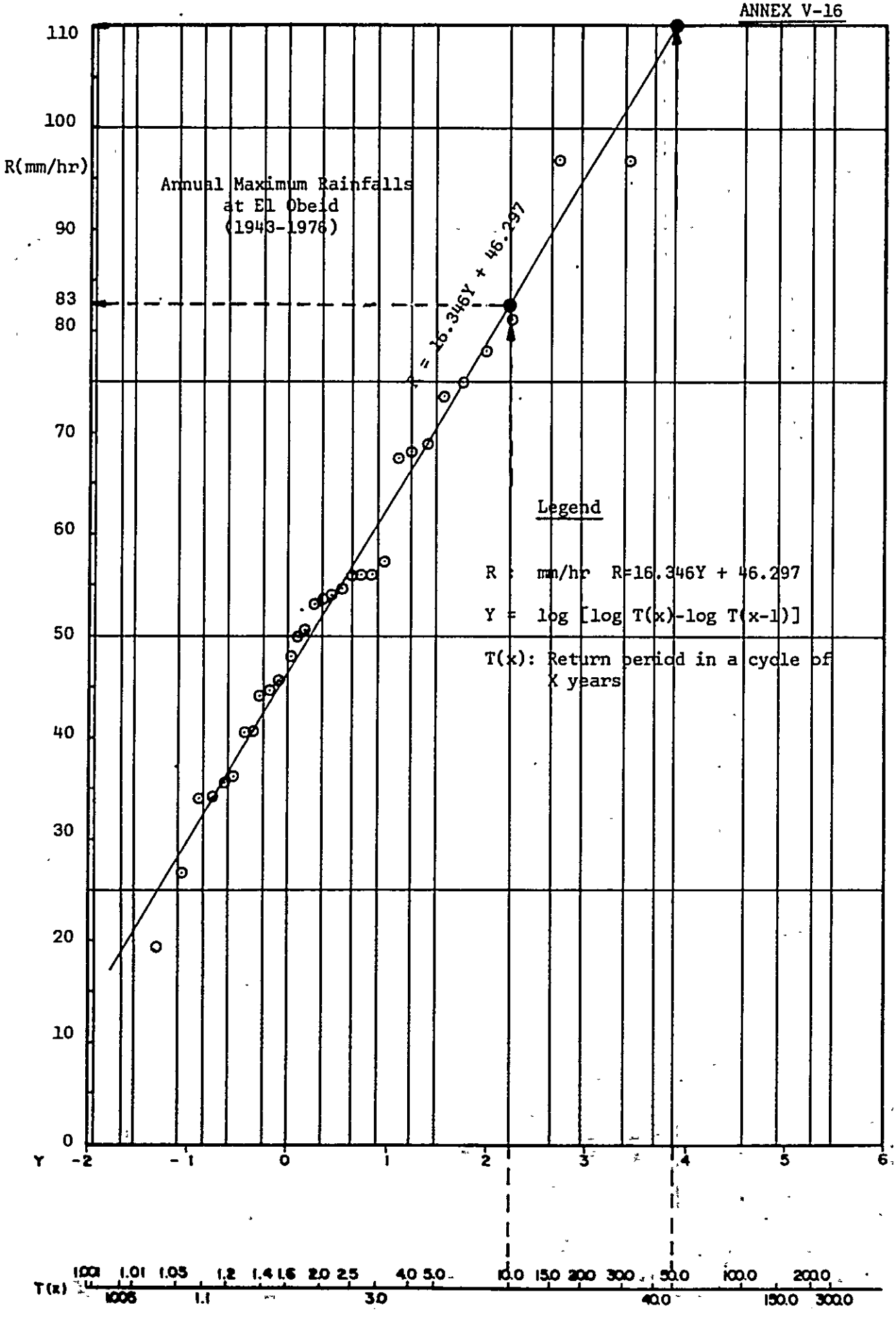
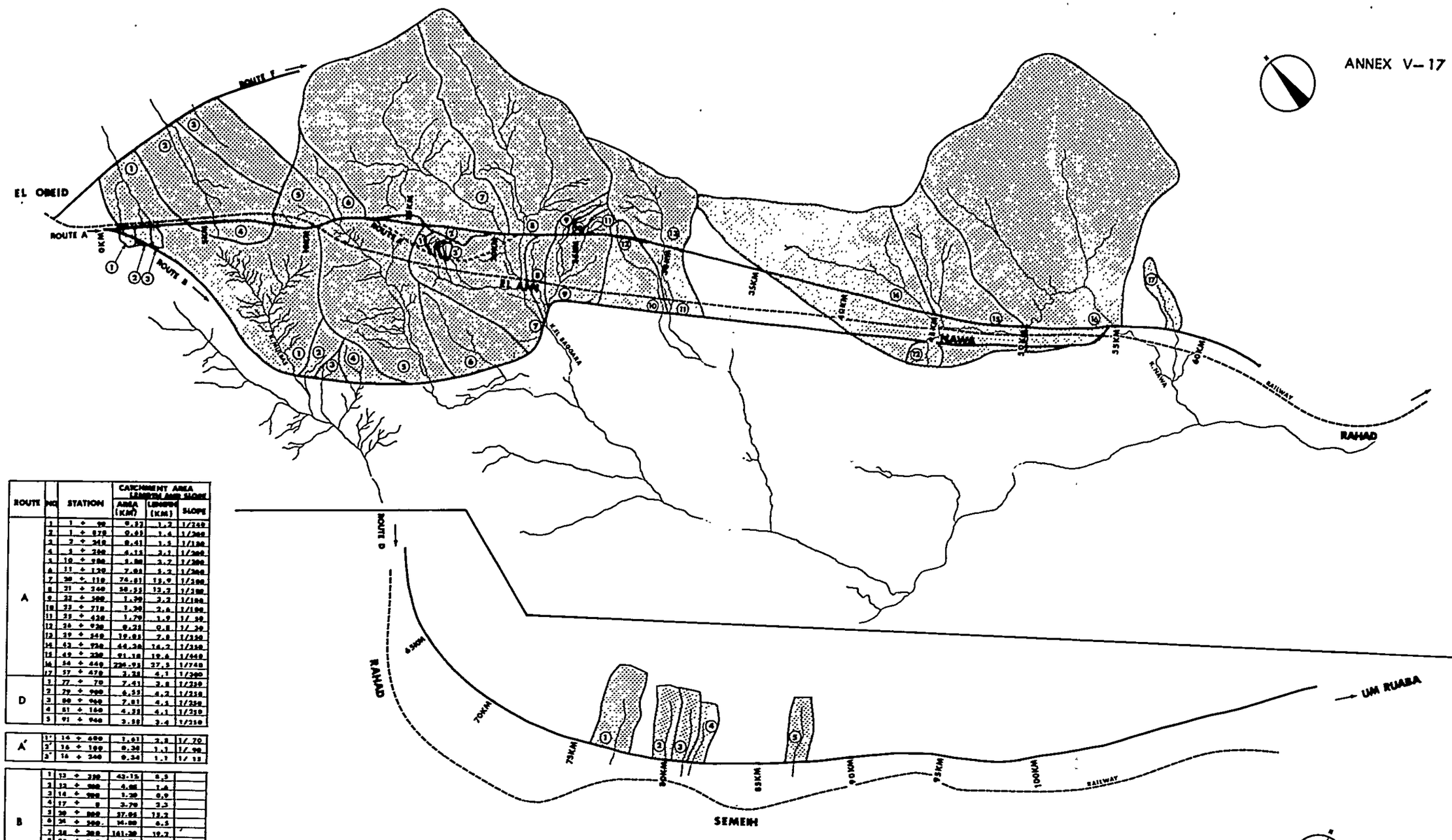


FIG. 5-13 CATCHMENT AREA

ANNEX V-17



ROUTE	NO	STATION	CATCHMENT AREA AREA (KM²)	LENGTH (KM)	SLOPE
A	1	1 + 00	0.32	1.2	1/240
	2	1 + 820	0.61	1.4	1/300
	3	2 + 340	0.41	1.5	1/150
	4	3 + 200	4.15	3.1	1/300
	5	10 + 980	1.80	3.2	1/300
	6	11 + 120	7.01	3.2	1/300
	7	30 + 110	74.81	13.9	1/300
	8	31 + 240	50.53	13.2	1/300
	9	32 + 500	1.30	3.2	1/100
	10	33 + 710	1.30	2.6	1/100
	11	35 + 430	1.79	1.9	1/ 30
	12	36 + 930	0.25	0.8	1/ 30
	13	39 + 240	19.83	7.8	1/250
	14	43 + 930	44.36	16.2	1/250
	15	49 + 230	91.18	19.6	1/440
	16	54 + 440	226.93	27.3	1/740
	17	57 + 470	3.28	4.1	1/300
D	1	77 + 70	7.41	3.8	1/250
	2	79 + 900	6.55	4.2	1/250
	3	80 + 940	7.81	4.3	1/250
	4	81 + 160	4.23	4.1	1/250
	5	91 + 940	3.38	3.4	1/250

A'	1'	14 + 600	1.61	2.8	1/ 70
	2'	16 + 100	0.30	1.1	1/ 90
	3'	16 + 240	0.34	1.1	1/ 33

B	1	12 + 330	43.15	8.3	
	2	13 + 980	6.85	1.4	
	3	14 + 980	5.30	6.9	
	4	17 + 0	3.79	3.3	
	5	20 + 800	37.05	13.3	
	6	24 + 340	34.80	6.5	
	7	26 + 200	161.30	19.7	
	8	28 + 700	3.70	4.6	
	9	29 + 600	15.90	8.8	
	10	33 + 820	11.60	6.6	
	11	36 + 330	35.60	9.8	
	12	38 + 330	2.30	1.6	

F	1	4 + 800	12.00	7.8	
	2	7 + 800	28.30	8.3	
	3	9 + 600	12.70	3.7	

FIG. 5-14-1. SPECIFIC RUN-OFF CURVES

(RETURN PERIOD: 10 YEARS)

f: run-off coefficient

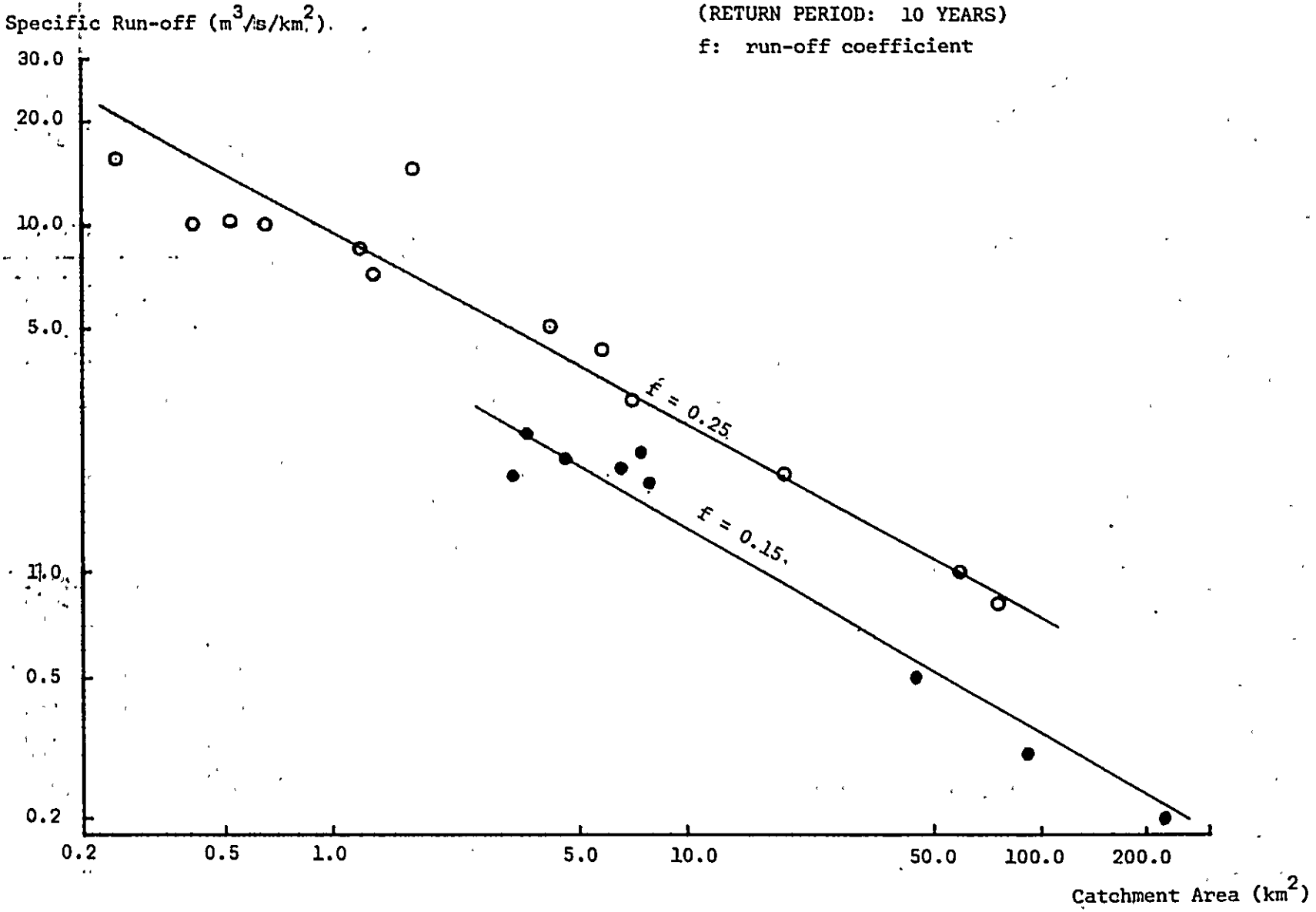


FIG. 5-14-2 SPECIFIC RUN-OFF CURVES

(RETURN PERIOD: 50 YEARS)

f: run-off coefficient

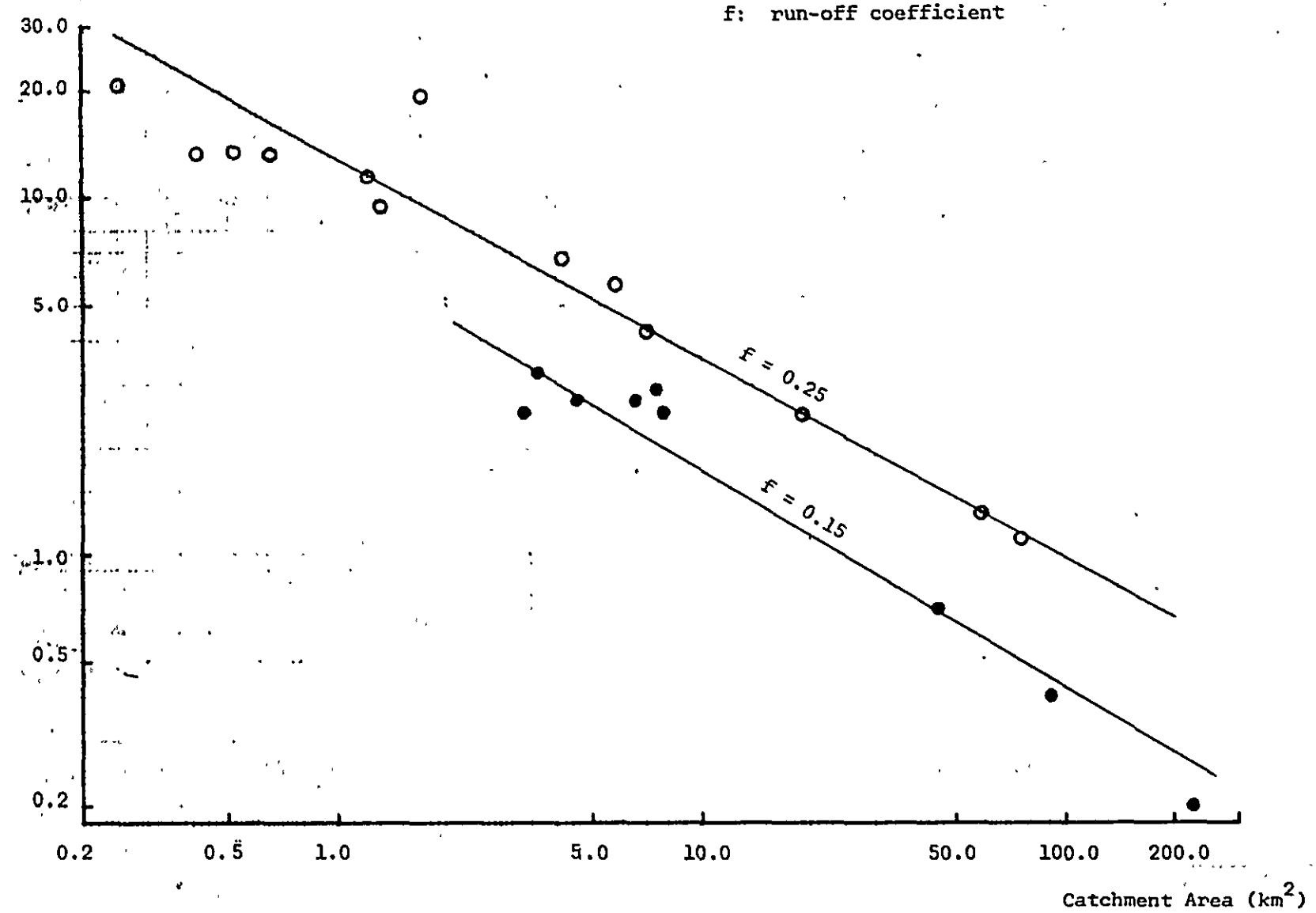


TABLE 5-11-1 ESTIMATED DISCHARGE OF 10 YEAR'S RETURN PERIOD AT THE LOCATION OF STRUCTURE.

Route A and D

$$r = \frac{5006}{t + 7.0}$$

Route	No.	Station	Catchment area Length and Slope			Time of concentration and Rainfall intensity		Run-off coefficient, Discharge and Specific run-off		
			Area (Km^2)	Length (Km)	Slope	Time of conc. (min)	Rainfall intensity (mm/hr)	Run-off coefficient	Discharge (m^3/s)	Specific run-off ($m^3/s/km^2$)
A	1	1k + 090m	0.52	1.2	1/240	27	147.2	0.25	5.3	10.2
	2	1k + 870m	0.65	1.4	1/200	28	143.0	"	6.5	10.0
	3	2k + 240m	0.41	1.5	1/180	28	143.0	"	4.1	10.0
	4	5k + 260m	4.15	3.1	1/200	62	72.6	"	20.9	5.0
	5	10k + 900m	5.80	3.7	1/200	74	61.8	"	24.9	4.3
	6	11k + 120m	7.05	5.2	1/200	104	45.1	"	22.1	3.1
	7	20k + 110m	74.81	15.9	1/300	406	12.1	"	62.9	0.8
	8	21k + 240m	58.55	13.2	1/300	337	14.6	"	59.4	1.0
	9	23k + 500m	1.30	3.2	1/100	42	102.2	"	9.2	7.1
	10	23k + 710m	1.20	2.6	1/100	34	122.1	"	10.2	8.5
	11	25k + 420m	1.70	1.9	1/ 50	17	208.6	"	24.6	14.5
	12	26k + 920m	0.25	0.8	1/ 30	15	227.5	"	3.9	15.6
	13	29k + 540m	19.05	7.8	1/250	179	26.9	"	35.6	1.9
	14	43k + 920m	44.30	14.2	1/350	398	12.4	0.15	22.9	0.5
	15	49k + 320m	91.10	19.6	1/440	630	7.9	"	30.0	0.3
	16	54k + 440m	224.95	27.5	1/740	1207	4.1	"	38.4	0.2
	17	57k + 470m	3.25	4.1	1/300	105	44.7	"	6.1	1.9
D	1	77k + 070m	7.41	3.8	1/250	87	53.2	"	16.4	2.2
	2	79k + 900m	6.55	4.2	1/250	96	48.6	"	13.3	2.0
	3	80k + 960m	7.81	4.5	1/250	103	45.5	"	14.8	1.9
	4	81k + 160m	4.55	4.1	1/250	94	49.6	"	9.4	2.1
	5	91k + 940m	3.58	3.4	1/250	78	58.9	"	8.8	2.5

TABLE 5-11-2 ESTIMATED DISCHARGE OF 50 YEAR'S RETURN PERIOD AT THE LOCATION OF STRUCTURE

Route A and D

$$r = \frac{6635}{t + 7.0}$$

Route	No.	Station	Catchment area Length and Slope			Time of concentration and Rainfall intensity		Run-off coefficient, Discharge and Specific run-off		
			Area (Km^2)	Length (Km)	Slope	Time of conc. (min)	Rainfall intensity (mm/hr)	Run-off coefficient	Discharge (m^3/s)	Specific run-off ($m^3/s/km^2$)
A	1	1k + 090m	0.52	1.2	1/240	27	195.1	0.25	7.0	13.5
	2	1k + 870m	0.65	1.4	1/200	28	189.6	"	8.6	13.2
	3	2k + 240m	0.41	1.5	1/180	28	189.6	"	5.4	13.2
	4	5k + 260m	4.15	3.1	1/200	62	96.2	"	27.7	6.7
	5	10k + 900m	5.80	3.7	1/200	74	81.9	"	33.0	5.7
	6	11k + 120m	7.05	5.2	1/200	104	59.8	"	29.3	4.2
	7	20k + 110m	74.81	15.9	1/300	406	16.1	"	83.6	1.1
	8	21k + 240m	58.55	13.2	1/300	337	19.3	"	78.5	1.3
	9	23k + 500m	1.30	3.2	1/100	42	135.4	"	12.2	9.4
	10	23k + 710m	1.20	2.6	1/100	34	161.8	"	13.5	11.3
	11	25k + 420m	1.70	1.9	1/ 50	17	276.5	"	32.6	19.2
	12	26k + 920m	0.25	0.8	1/ 30	15	301.6	"	5.2	20.8
	13	29k + 540m	19.05	7.8	1/250	179	35.7	"	47.2	2.5
	14	43k + 920m	44.30	14.2	1/350	398	16.4	0.15	30.3	0.7
	15	49k + 320m	91.10	19.6	1/440	630	10.4	"	39.5	0.4
	16	54k + 440m	224.95	27.5	1/740	1207	5.5	"	51.6	0.2
	17	57k + 470m	3.25	4.1	1/300	105	59.2	"	8.0	2.5
D	1	77k + 070m	7.41	3.8	1/250	87	70.6	"	21.8	2.9
	2	79k + 900m	6.55	4.2	1/250	96	64.4	"	17.6	2.7
	3	80k + 960m	7.81	4.5	1/250	103	60.3	"	19.6	2.5
	4	81k + 160m	4.55	4.1	1/250	94	65.7	"	12.5	2.7
	5	91k + 940m	3.58	3.4	1/250	78	78.1	"	11.6	3.2

TABLE 5-11-3 ESTIMATED DISCHARGE OF 10 YEAR'S RETURN PERIOD AT THE LOCATION OF STRUCTURE BY SPECIFIC RUN-OFF CURVES

Route B

No.	Station	Catchment area Length and Slope			Time of concentration and Rainfall intensity		Run-off coefficient, Discharge and Specific run-off		
		Area (Km^2)	Length (Km)	Slope	Time of conc. (min)	Rainfall intensity (mm/hr)	Run-off coefficient	Discharge (m^3/s)	Specific run-off ($m^3/s/km^2$)
1	13k + 350m	43.15	8.5					50.1	1.16
2	13k + 950m	4.05	1.6					17.8	4.40
3	14k + 900m	1.20	0.9					10.2	8.50
4	17k + 000m	3.70	2.3					17.0	4.60
5	20k + 800m	57.05	15.2					58.8	1.03
6	24k + 500m	14.80	6.5					31.7	2.14
7	28k + 300m	161.30	19.2					90.3	0.56
8	28k + 700m	3.70	4.6					17.0	4.60
9	29k + 400m	15.90	8.0					32.6	2.05
10	35k + 850m	11.40	6.4					27.9	2.45
11	36k + 250m	25.60	9.0					40.4	1.58
12	50k + 350m	2.20	1.4					13.4	6.10

Route F

1	4k + 800m	12.05	7.0					28.9	2.40
2	7k + 800m	28.30	8.5					42.5	1.50
3	9k + 600m	13.70	3.2					30.1	2.20

Remarks; Discharges are obtained from FIG. 5-14-1 SPECIFIC RUN-OFF CURVES.

TABLE 5-11-4 ESTIMATED DISCHARGE OF 50 YEAR'S RETURN PERIOD AT THE LOCATION OF STRUCTURE BY SPECIFIC RUN-OFF CURVES

Route B

No.	Station	Catchment area Length and Slope			Time of concentration and Rainfall intensity		Run-off coefficient, Discharge and Specific run-off		
		Area (Km^2)	Length (Km)	Slope	Time of conc. (min)	Rainfall intensity (mm/hr)	Run-off coefficient	Discharge (m^3/s)	Specific run-off ($m^3/s/km^2$)
1	13k + 350m	43.15	8.5					67.7	1.57
2	13k + 950m	4.05	1.6					23.9	5.90
3	14k + 900m	1.20	0.9					13.8	11.50
4	17k + 000m	3.70	2.3					22.9	6.20
5	20k + 800m	57.05	15.2					76.4	1.34
6	24k + 500m	14.80	6.5					42.2	2.85
7	28k + 300m	161.30	19.2					119.4	0.74
8	28k + 700m	3.70	4.6					22.9	6.20
9	29k + 400m	15.90	8.0					43.2	2.72
10	35k + 850m	11.40	6.4					37.1	3.25
11	36k + 250m	25.60	9.0					53.8	2.10
12	50k + 350m	2.20	1.4					18.0	8.20

Route F

1	4k + 800m	12.05	7.0					38.6	3.20
2	7k + 800m	28.30	8.5					56.6	2.00
3	9k + 600m	13.70	3.2					41.1	3.00

Remarks; Discharges are obtained from FIG. 5-14-2 SPECIFIC RUN-OFF CURVES.

ANNEX VI

TABLE 6-1 ROAD-SIDE INTERVIEW QUESTIONNAIRE

Station No.		Name of interviewer	Sheet No.	1 Time of interview	2 Type of vehicle
Date of interview				1: 7~8; 2: 8~9; 3: 9~10; 4: 10~11; 5: 11~12; 6: 12~13; 7: 13~14; 8: 14~15; 9: 15~16; 10: 16~17; 11: 17~18; 12: 18~19	1 Car, taxi; 2 Jeep; 3 Van, pick-up; 4 Medium truck; 5 Heavy truck; 6. Truck-trailer; 7. Bus; 8. Motor cycle; 9. Animal-drawn vehicle; 10. Others
Weather		Name of Surveyor	/		
Direction					
←					

Model of The vehicle		5	6	7 Trip purpose	Passenger cars		Trucks				14 Fuel used	15
3 Model/ Make	4 Age	Origin Name of the place where you start the trip	Destination Name of the place where you finally finish the trip	1 Work 2 To home 3 Shopping 4 Social intercourse recreation 5 Others	8 Capacity (No. of persons)	9 No of passengers	10 No. of wheels	11 Loading capacity (tons)	12 Type of commodities carried	13 Weight of commodity (tons)	1 Gasoline 2 Diesel 3 Others	Average annual mileage of the car (kilometer per year)

1 Time	2 Type of vehicle	3 Model/make of the vehicle	4 Age	5 Origin	6 Destination	7 1)	8 Capacity	9 No. of pass.	10 No. of wheels	11 Loading capacity	12 Types of commodity carried	13 weight	14 Fuel used	15 2)

Notes: 1) Travel Time

2) Fuel Consumption

TABLE 6-2 TRAFFIC COUNT SURVEY SHEET ANNEX VI-2

Station No.		Date of count		Weather		Sheet No.
Direction		Name of Surveyor		Name of Supervisor		
→						/

Type of vehicle	7 ~ 8	8 ~ 9	9 ~ 10	10 ~ 11	11 ~ 12	12 ~ 13	13 ~ 14	14 ~ 15	15 ~ 16	16 ~ 17	17 ~ 18	18 ~ 19	Total
1. Car, taxi 													
2. Jeep 													
3. Van, pick-up 													
4. Medium truck 													
5. Heavy truck 													
6. Truck-trailer 													
7. Bus 													
8. Motor cycle													
9. Animal drawn vehicle													
10. Others													
Total													

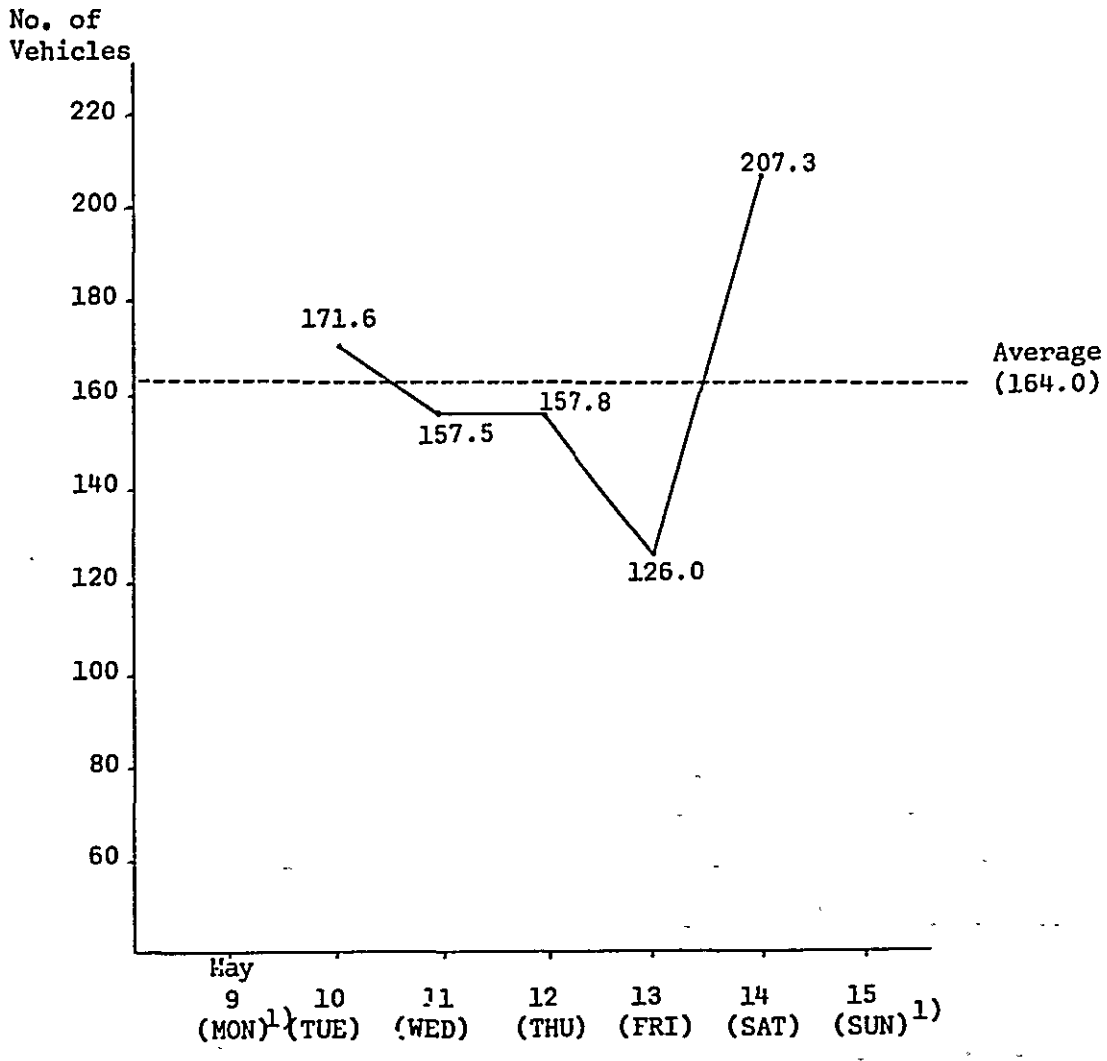
TABLE 6-3 DAILY TRAFFIC AT SURVEY STATIONS, EL OBEID

Vehicle Type	May 9[2] (MON)	10 (TUE)	11 (WED)	12 (THU)	13 (FRI)	14 (SAT)	15[2] (SUN)	Average[1]
Station 1-1								
Van/pick-up	1.2	-	3.6	-	-	-	1.2	0.7
Medium Truck	56.4	43.2	49.2	42.0	34.8	82.8	20.4	50.4
Heavy Truck	1.2	2.4	4.8	1.2	1.2	2.4	-	2.4
Bus	1.2	-	-	-	-	-	-	-
Total	60.0	45.6	57.6	43.2	36.0	85.2	21.6	53.5
Station 1-2								
Van/pick-up	3.6	4.8	2.4	1.2	15.6	-	1.2	4.8
Medium Truck	20.4	48.0	34.8	48.0	34.8	45.6	21.6	42.2
Heavy Truck	-	-	-	1.2	1.2	-	-	0.5
Bus	-	1.2	1.2	1.2	2.4	-	1.2	1.2
Total	24.0	54.0	38.4	51.6	54.0	45.6	24.0	48.7
Station 1-3								
Van/pick-up	-	-	1.5	1.5	-	1.5	3.0	0.9
Medium Truck	25.5	22.5	30.0	30.0	19.5	48.0	18.0	30.0
Heavy Truck	-	3.0	1.5	3.0	3.0	1.5	1.5	2.4
Bus	-	-	-	-	-	-	-	-
Total	25.5	25.5	33.0	34.5	22.5	51.0	22.5	33.3
Station 1-4								
Van/pick-up	4.5	16.5	7.5	6.0	6.0	9.0	-	9.0
Medium Truck	7.5	22.5	12.0	16.5	3.0	13.5	-	13.5
Heavy Truck	-	-	3.0	-	1.5	-	-	0.9
Bus	4.5	7.5	6.0	6.0	3.0	3.0	-	5.1
Total	16.5	46.5	28.5	28.5	13.5	25.5	-	28.5

Notes : 1) This figure is an average of Tuesday to Saturday.
2) The survey did not cover the traffic for 24 hours.

FIG. 6-1 DAILY VARIATION OF ROAD TRAFFIC, EL OBEID, MAY, 1977

(ALL TYPES OF VEHICLES)

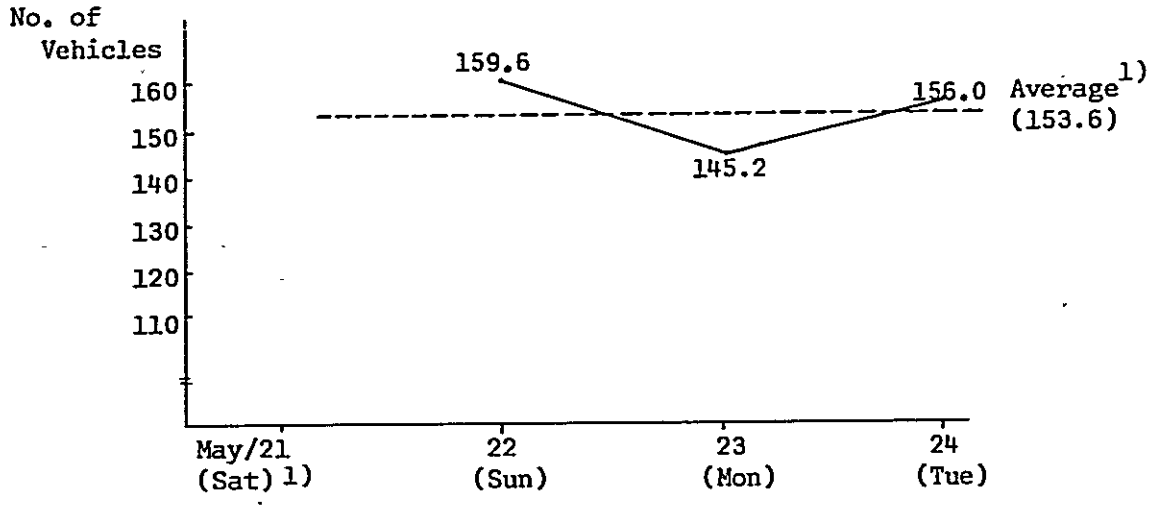


Note : 1) Survey was not conducted for a full day.

TABLE 6-4 DAILY TRAFFIC AT SURVEY STATIONS, UM RUABA

Vehicle Type	May 21 (Sat) [2]	22 (Sun)	23 (Mon)	24 (Tue)	Average [1]
Station 2-1					
Van/pick-up	6.0	1.2	4.8	7.2	4.4
Medium Truck	38.4	38.4	28.8	27.6	31.6
Heavy Truck	-	-	-	-	-
Bus	-	-	-	-	-
Total	44.4	39.6	33.6	34.8	36.0
Station 2-2					
Van/pick-up	1.2	-	-	1.2	0.4
Medium Truck	69.6	117.6	104.4	117.6	113.2
Heavy Truck	-	2.4	7.2	2.4	4.0
Bus	1.2	-	-	-	-
Total	72.0	120.0	111.6	121.2	117.6

FIG. 6-2 DAILY VARIATION OF ROAD TRAFFIC, UM RUABA, MAY 1977
(ALL TYPES OF VEHICLES)



Notes: 1) This figure in an average of Sunday to Tuesday.
2) The survey did not cover the traffic for 24 hours.

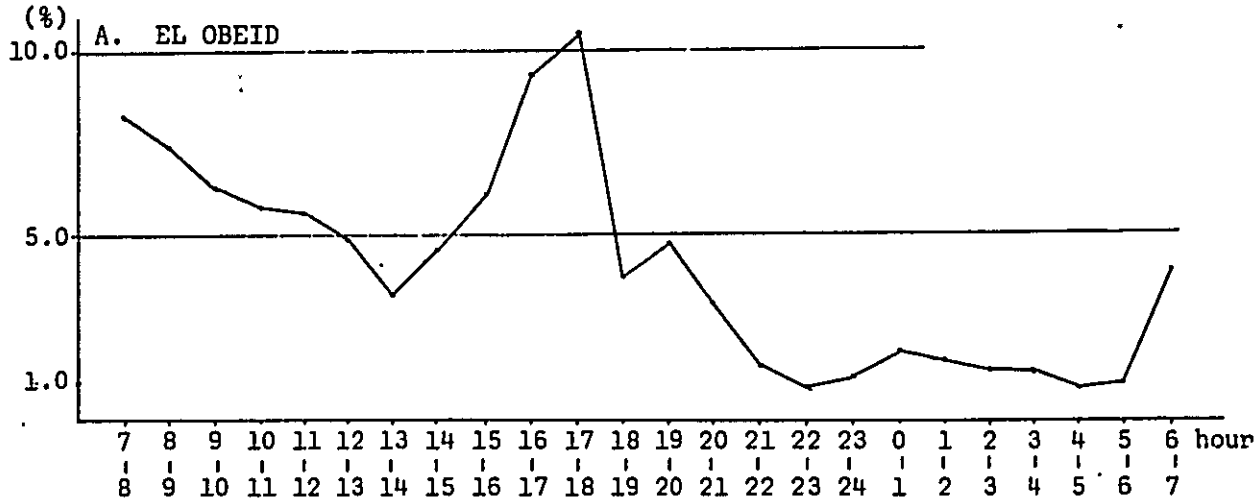
TABLE 6-5-1 HOURLY DISTRIBUTION OF ADT, EL OBEID AREA, MAY, 1977

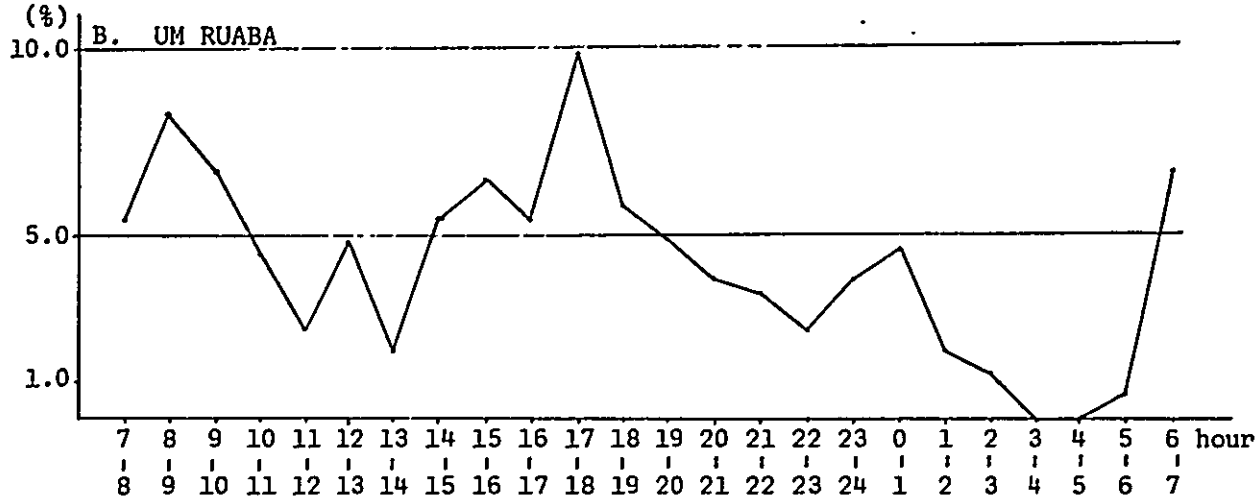
Hour	Van/ pick-up	Medium Truck	Heavy Truck	Bus	Total Vehicles	%
7 - 8	1.5	11.1	0.4	0.2	13.2	8.3
8 - 9	1.7	7.9	0.2	2.0	11.8	7.4
9 - 10	0.5	8.4	0.4	0.8	10.1	6.3
10 - 11	0.2	8.3	0.6	0.2	9.3	5.8
11 - 12	0.9	7.5	0.6	-	9.0	5.6
12 - 13	0.7	6.6	0.6	-	7.9	4.9
13 - 14	0.4	4.6	0.5	-	5.5	3.4
14 - 15	0.6	6.6	-	0.2	7.4	4.6
15 - 16	-	6.2	0.6	3.0	9.8	6.1
16 - 17	1.8	13.2	-	-	15.0	9.4
17 - 18	1.5	14.6	0.4	0.2	16.7	10.5
18 - 19	0.2	5.9	0.2	-	6.3	3.9
19 - 20	1.2	6.3	0.2	-	7.7	4.8
20 - 21	1.0	4.1	-	-	5.1	3.2
21 - 22	0.5	1.9	-	-	2.4	1.5
22 - 23	0.4	1.1	-	-	1.5	0.9
23 - 24	0.4	1.5	-	-	1.9	1.2
0 - 1	1.1	1.9	-	-	3.0	1.9
1 - 2	0.6	1.9	-	-	2.5	1.6
2 - 3	-	2.2	-	-	2.2	1.4
3 - 4	0.2	1.6	-	0.2	2.0	1.3
4 - 5	-	1.4	-	-	1.4	0.9
5 - 6	-	1.6	-	-	1.6	1.0
6 - 7	-	6.3	0.2	-	6.5	4.1
Total	15.4	132.7	4.9	6.8	159.8	100.0

TABLE 6-5-2 HOURLY DISTRIBUTION OF ADT, UM RUABA AREA, MAY, 1977

Hour	Van/ pick-up	Medium Truck	Heavy Truck	Bus	Total Vehicles	%
7 - 8	-	6.9	1.2	-	8.1	5.4
8 - 9	0.3	12.0	-	0.3	12.6	8.3
9 - 10	0.9	9.3	-	-	10.2	6.7
10 - 11	0.3	6.3	-	-	6.6	4.4
11 - 12	0.3	3.3	-	-	3.6	2.4
12 - 13	-	6.9	0.3	-	7.2	4.8
13 - 14	-	2.4	0.3	-	2.7	1.8
14 - 15	1.2	6.6	0.3	-	8.1	5.4
15 - 16	-	9.9	-	-	9.9	6.5
16 - 17	0.3	7.8	-	-	8.1	5.4
17 - 18	1.2	13.8	-	-	15.0	9.9
18 - 19	0.9	7.2	0.6	-	8.7	5.8
19 - 20	-	7.5	-	-	7.5	4.9
20 - 21	-	5.7	-	-	5.7	3.8
21 - 22	-	5.1	-	-	5.1	3.4
22 - 23	-	3.3	0.3	-	3.6	2.4
23 - 24	-	5.7	-	-	5.7	3.8
0 - 1	-	6.9	-	-	6.9	4.6
1 - 2	-	2.7	-	-	2.7	1.8
2 - 3	-	1.8	-	-	1.8	1.2
3 - 4	-	-	-	-	-	-
4 - 5	-	-	-	-	-	-
5 - 6	0.3	0.6	-	-	0.9	0.6
6 - 7	-	10.2	-	-	10.2	6.7
Total	5.7	141.9	3.0	0.3	150.9	100.0

FIG. 6-3-1 HOURLY DISTRIBUTION OF ADT, 1977
(ALL TYPES OF VEHICLES)





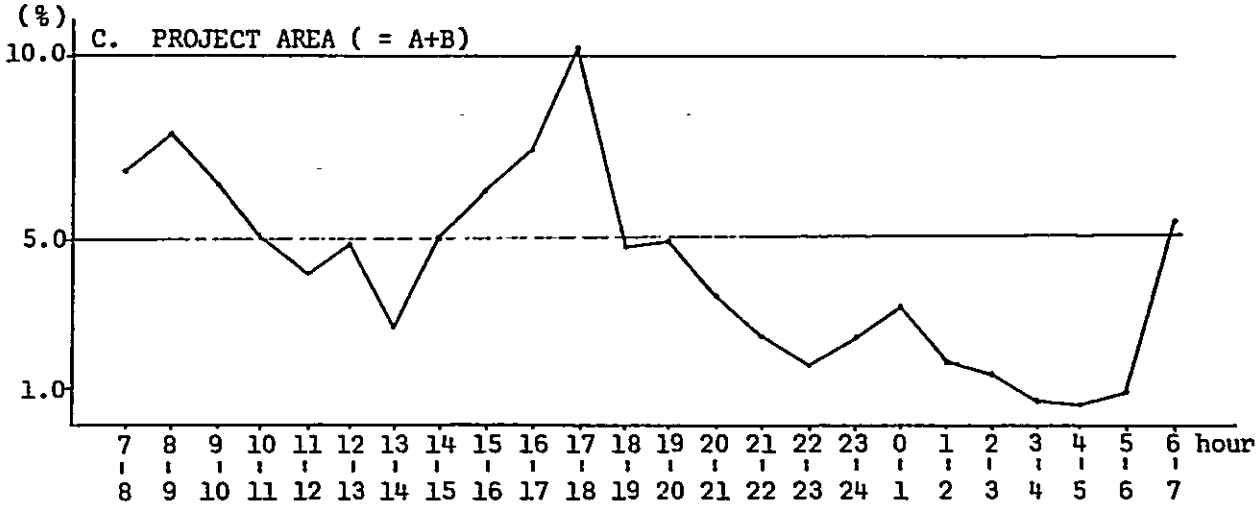


TABLE 6-6-1 SEASONAL VARIATION OF RAILWAY GOODS TRAFFIC AT EL OBEID STATION, 1976

Month	Forwarded	Received	Total
1976			
JAN.	11,580	8,417	19,997
FEB.	8,936	7,232	16,168
MAR.	6,952	6,499	13,451
APR.	11,507	7,067	18,574
MAY	9,672	8,254	17,926
JUN.	9,249	7,349	16,598
JUL.	9,356	8,476	17,832
AUG.	9,401	9,244	18,645
SEP.	7,390	8,466	15,856
OCT.	6,317	7,254	13,571
NOV.	8,425	7,753	16,178
DEC.	8,766	7,249	16,015
Total	107,551	93,260	200,811
Average	8.963	7.772	16.735

Source: Sudan Railways Corporation, 1977

FIG. 6-4-1 SEASONAL VARIATION OF RAILWAY GOODS TRAFFIC AT EL OBEID STATION, 1976

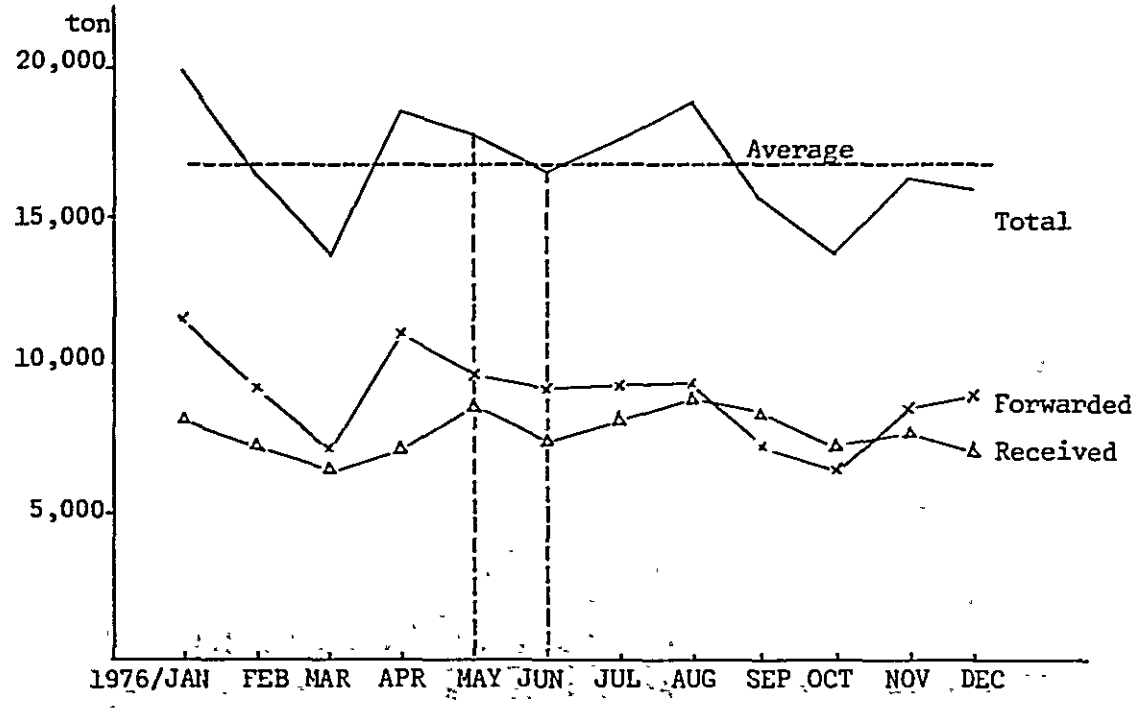


TABLE 6-6-2 SEASONAL VARIATION OF TONNAGE OF CROPS HANDLED AT EL OBEID CROP MARKET, 1976

Month	Tons
JAN. 1976	104,000
FEB.	95,000
MAR.	87,000
APR.	69,000
MAY	74,000
JUN.	44,000
JUL.	17,000
AUG.	4,000
SEP.	1,000
OCT.	27,000
NOV.	99,000
DEC.	87,000
Total	708,000
Average	59,000

Source: El Obeid Crop Market, 1977

FIG. 6-4-2 SEASONAL VARIATION OF TONNAGE OF CROPS HANDLED AT EL OBEID CROP MARKET, 1976

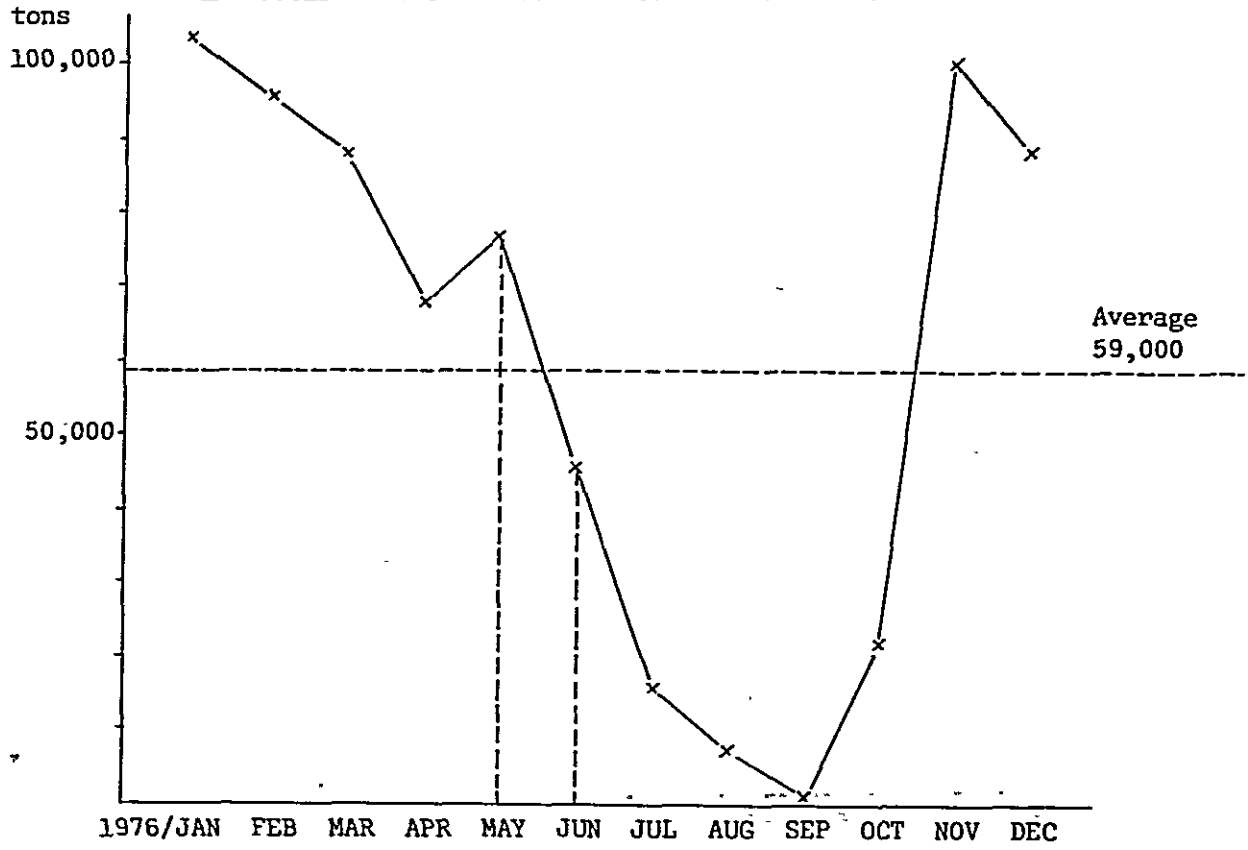


TABLE 6-7 VEHICLE MAKE AND YEARS IN SERVICE

Vehicle Make \ Years in Service		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total No.	Total %
Volga(1/4)							1.5	1.5										3.0	0.2
Jeep(0.5)		1.2		3.6	1.2	1.2	2.4	1.2	2.4	1.2		1.2	1.2				1.2	18.0	1.1
Land Rover(1.0)		1.2	2.4	3.9	7.5	7.2	4.5											26.7	1.6
Ford Custom(1.5)			7.5	3.6	1.5	1.5	2.4	1.5				1.2						19.2	1.2
Toyota(1.5)		1.2					1.2				2.7							5.1	0.3
Mercury (3.0)			1.5		1.5	1.2	3.9		1.5	1.5	1.5	3.0					3.0	18.6	1.1
Commer(3.0)				1.2	1.2		3.6	1.5		1.5		1.2						10.2	0.6
Ford(4.0)			1.2	3.9	5.4	4.2	1.5				1.5			1.2				18.9	1.1
Commer(5.0)			1.2	3.6	2.4	2.4	5.1	5.1		4.2	3.0	3.0	1.2	2.4	1.2			34.8	2.1
Austin(5.0)		15.9	51.0	43.5	45.0	32.4	8.4	7.2	2.7	9.0	2.4	3.6		1.2			3.6	225.9	13.7
Austin(6.0)		16.8	34.2	18.0	18.6	16.5	10.2	6.0	1.2	1.5				1.5			2.4	126.9	7.7
Bed Ford(6.0)		11.1	43.5	110.1	97.2	87.6	42.3	43.2	10.8	16.8	8.4	14.4	2.4	1.2			1.2	490.2	29.7
Ford(6.0)			15.9	52.5	30.3	52.5	22.5	16.2	6.6	2.4		2.4		1.2				202.5	12.3
International(6.0)			1.2			2.4												3.6	0.2
Ford(7.0)			4.5	6.3	52.8	42.0	19.5	19.8	9.3	8.1	3.0	4.2			1.2			170.7	10.4
Nissan(8.0)		6.0	22.5	44.4	42.9	22.5	15.9	3.9	3.0	1.5				1.2				163.8	9.9
Mageros(8.0)			19.2	27.0														46.2	2.8
Fuso(8.0)			1.2							1.2								2.4	0.1
Hino(8.0)			2.4	6.9	5.1													14.4	0.9
Fiat(11.0)		1.5	5.4	15.0	2.7													24.6	1.5
Leyland(12.0)			2.4															2.4	0.1
Super(15.0)			1.2															1.2	0.1
Scania(16.0)				2.4	1.2	1.5												5.1	0.3
Nissan(16.0)			2.4	1.5														3.9	0.2
Bassit(6.0)				1.2	1.2				1.2									3.6	0.2
Liner(16.0)				6.0														6.0	0.4
Total	Number	54.9	220.8	354.6	317.7	275.1	144.9	107.1	38.7	48.9	22.5	34.2	4.8	9.9	2.4		11.4	1647.9	100.0
	%	3.4	13.4	21.5	19.3	16.7	8.8	6.5	2.3	3.0	1.4	2.1	0.3	0.6	0.1		0.7	100.0	

Note: 1) Figures in parenthesis indicate loading capacity in tons.

TABLE 6-8 YEARS IN SERVICE OF VEHICLES BY TYPE [1)]

Vehicle Type	Years in Service																Total (%)	Average Years in Service
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Van/pick-up	3.6	9.9	11.1	10.2	9.9	12.0	4.2	2.4	1.2	2.7	2.4	1.2	-	-	-	1.2	72.0 (4.5)	4.1
Medium Truck	48.3	180.3	290.4	299.4	258.0	118.2	98.7	32.1	45.0	19.8	27.0	3.6	9.9	2.4	-	10.2	1,443.3 (90.1)	3.6
Heavy Truck	1.5	11.4	26.1	5.1	1.5	-	-	1.2	-	-	-	-	-	-	-	-	46.8 (2.9)	2.0
Bus	1.5	-	-	3.0	5.7	14.7	4.2	3.0	2.7	-	4.8	-	-	-	-	-	39.6 (2.5)	5.6
Total	54.9	201.6	327.6	317.7	275.1	144.9	107.1	38.7	48.9	22.5	34.2	4.8	9.9	2.4	-	11.4	1,601.7	3.7
(%)	(3.4)	(12.6)	(20.5)	(19.8)	(17.2)	(9.0)	(6.7)	(2.4)	(3.1)	(1.4)	(2.1)	(0.3)	(0.6)	(0.1)	-	(0.7)	(100.0)	

Note: 1) Vehicles for military use are excluded.

TABLE 6-9 DISTRIBUTION OF VEHICLES BY LOADING CAPACITY [1)]

Vehicle Type	Van/pick-up					Medium Truck							Heavy Truck					TOTAL
Capacity (ton)	0.25	0.5	1	1.5	Total	3	4	5	6	7	8	Total	11	12	15	16	Total	
Number of Vehicle	3.0	18.0	26.7	24.3	72.0	18.8	18.9	260.7	793.5	170.7	170.7	1,443.3	24.6	2.4	1.2	18.6	46.8	1,562.1
Average Capacity (ton)			1.0							6.1					13.1			6.1

Note: 1) Vehicles for military use and buses are excluded.

TABLE 6-10 DISTRIBUTION OF VEHICLES BY LOAD CONTENT [1)]

	Number of Vehicles			(Vehicles)	
	Van Pick-up	Medium Truck	Heavy Truck	Total	(%)
Commodities only		83.7	6.4	90.1	(6)
Commodities & Passengers	9.4	1,166.7	31.8	1,207.9	(77)
Passengers only	55.8	173.9	7.3	237.0	(15)
Empty	6.8	19.0	1.3	27.1	(2)
Total	72.0	1,443.3	46.8	1,562.1	(100)

Note: 1) Vehicles for military use and buses are excluded.

TABLE 6-11 LOADING CHARACTERISTICS OF VEHICLES[1)]

		Type of Vehicles			
		Van Pick-up	Medium Truck	Heavy Truck	Total
Average Loaded Tonnage (ton)	Commodities only		4.91	8.43	5.15
	Commodities & Passengers	0.73	4.78	9.04	4.84
	Average	0.73	4.79	8.93	4.87
	Av.Incl. empty Veh.	0.11	4.14	7.19	4.03
Average Loaded Passengers (persons)	Commodities & Passengers	4.37	9.49	9.03	9.44
	Passengers only	5.35	14.63	4.20	12.08
	Average	4.71	9.44	6.54	9.13
Average Loading Rate (%)	Commodities only		80	60	77
	Commodities & Passengers	53	78	72	78
	Average	53	78	70	77
	Av. Incl. empty Veh.	09	68	54	67

Note: 1) Vehicles for military use and buses are excluded.

TABLE 6-12-1 OD TABLE OF ROAD VEHICULAR TRAFFIC, 1977

(All types of vehicles)

(Vehicles per day)

ZONE		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL
EL OBEID	01		6.2			14.9		1.0	22.3	1.0	1.8	1.0	14.1	0.8	40.3	0.1	1.3		2.7	0.5	0.8						108.8
GEIFIL	02					0.6							0.6														7.4
ET TAIYARA	03					0.1																					0.1
SHAMAGATTA	04					16.5							0.3		0.6		0.3										17.7
UM RUABA	05						3.9	2.1	11.1											6.9	2.1		0.1	0.9			59.2
ABU HAMRA	06																										3.9
SEMEIH	07														0.3												3.4
RAHAD	08											1.5	2.4		3.0								0.7				41.0
NAWA	09																										1.0
EL AIN	10														0.2												2.0
TENDELTI	11																			0.3	0.6		0.3				3.7
KOSTI-SENNAR	12																			0.3	6.6		0.2	0.1			24.6
WAD MEDANI	13																				0.9						1.7
KHARTOUM	14																			0.6	5.4	0.4	1.8	15.6			68.2
KASSALA	15																										0.1
PORT SUDAN	16																							0.3			1.9
MALAKAL	17																										
EL ABBASIYA	18																										2.7
NUBA' MOUNTAIN	19																										8.6
KADUGLI-DILLING	20																										16.4
WAU-JUBA	21																										0.4
EN NAHUD	22																										3.1
NYALA .	23																										16.9
BARA	24																										
ATBARA	25																										
TOTAL																											392.8

TABLE 6-12-2 OD TABLE OF ROAD VEHICULAR TRAFFIC, 1977

(Van Pick-up)

(Vehicles per day)

ZONE		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL
EL OBEID	01		0.2			1.1		0.2	1.2	0.2	1.4		0.3		1.2				0.4	0.2	0.6						7.0
GEIFIL	02																										0.2
ET TAIYARA	03																										
SHAMAGATTA	04					3.0																					3.0
UM RUABA	05								0.3														0.1	0.3			4.8
ABU HAMRA	06																										
SEMEIH	07																										0.2
RAHAD	08																										1.5
NAWA	09																										0.2
EL AIN	10																										1.4
TENDELTI	11																										
KOSTI-SENNAR	12																										0.3
WAD MEDANI	13																										
KHARTOUM	14																										1.2
KASSALA	15																										
PORT SUDAN	16																										
MALAKAL	17																										
EL ABBASIYA	18																										0.4
NUBA MOUNTAIN	19																										0.2
KADUGLI-DILLING	20																										0.6
WAU-JUBA	21																										
EN NAHUD	22																										0.1
NYALA	23																										0.3
BARA	24																										
ATBARA	25																										
TOTAL																											21.4

TABLE 6-12-3 OD TABLE OF ROAD VEHICULAR TRAFFIC, 1977

(Medium Truck)

(Vehicles per day)

ZONE		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL
EL OBEID	01		6.0			13.4		0.4	19.4	0.8	0.4	1.0	13.8	0.8	36.4	0.1	1.6		2.3	0.3	0.2						96.9
GEIFIL	02					0.6							0.6														7.2
ET TAIYARA	03					0.1																					0.1
SHAMAGATTA	04					13.5							0.3		0.6		0.3										14.7
UM RUABA	05						3.9	2.1	10.8											6.9	2.1			0.6			54.0
ABU HAMRA	06																										3.9
SEMEIH	07														0.3												2.8
RAHAD	08											1.5	2.4		3.0								0.7				37.8
NAWA	09																										0.8
EL AIN	10														0.2												0.6
TENDELTI	11																			0.3	0.6		0.3				3.7
KOSTI-SENNAR	12																			0.3	6.3		0.2	0.1			24.0
WAD MEDANI	13																				0.9						1.7
KHARTOUM	14																			0.6	4.8	0.4	1.8	14.6			62.7
KASSALA	15																										0.1
PORT SUDAN	16																							0.3			2.2
MALAKAL	17																										
EL ABBASIYA	18																										2.3
NUBA MOUNTAIN	19																										8.4
KADUGLI-DILLING	20																										14.9
WAU-JUBA	21																										0.4
EN NAHUD	22																										3.0
NYALA	23																										15.6
BARA	24																										
ATBARA	25																										
TOTAL																											357.8

TABLE 6-12-4 OD TABLE OF ROAD VEHICULAR TRAFFIC, 1977

(Heavy Truck)

(Vehicles per day)

ZONE		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL
EL OBEID	01					0.3		0.4	0.4						2.4												3.5
GEIFIL	02																										
ET TAIYARA	03																										
SHAMAGATTA	04																										
UM RUABA	05																										0.3
ABU HAMRA	06																										
SEMEIH	07																										0.4
RAHAD	08																										0.4
NAWA	09																										
EL AIN	10																										
TENDELTI	11																										
KOSTI-SENNAR	12																				0.3						0.3
WAD MEDANI	13																										
KHARTOUM	14																				0.6			0.9			3.9
KASSALA	15																										
PORT SUDAN	16																										
MALAKAL	17																										
EL ABBASIYA	18																										
NUBA MOUNTAIN	19																										
KADUGLI-DILLING	20																										0.9
WAU-JUBA	21																										
EN NAHUD	22																										
NYALA	23																										0.9
BARA	24																										
ATBARA	25																										
TOTAL																											10.6

TABLE 6-12-5 OD TABLE OF ROAD VEHICULAR TRAFFIC, 1977

(BUS)

(Vehicles per day)

ZONE		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL
EL OBEID	01								1.3						0.2												1.5
GEIFIL	02																										
ET TAIYARA	03																										
SHAMAGATTA	04																										
UM RUABA	05																										
ABU HAMRA	06																										
SEMEIH	07																										
RAHAD	08																										1.3
NAWA	09																										
EL AIN	10																										
TENDELTI	11																										
KOSTI-SENNAR	12																										
WAD MEDANI	13																										
KHARTOUM	14																										0.2
KASSALA	15																										
PORT SUDAN	16																										
MALAKAL	17																										
EL ABBASIYA	18																										
NUBA MOUNTAIN	19																										
KADUGLI-DILLING	20																										
WAU-JUBA	21																										
EN NAHUD	22																										
NYALA	23																										
BARA	24																										
ATBARA	25																										
TOTAL																											3.0

TABLE 6-13 CLASSIFICATION OF COMMODITIES

Code No.	Commodity Group	Name of Commodity
10	Unprocessed cereals	Dura, Maize
20	Other unprocessed agricultural foodstuffs	Onions, Vegetables, Dates, Aradaib, Beans, Mango, Fruits, Milk, Ganzabeel
31	Unprocessed agricultural cash crops	31. Gum Arabic
32		32. Groundnuts
33		33. Karkadeh
34		34. Watermelon Seeds
35		35. Simsim
36		36. Umbas (Foodstuffs for Animals)
37		37. Cotton
30		30. Others
40	Processed cereal products	Flour, Rice
50	Manufactured foodstuffs	Beer, Wine, Tea, Coffee, Biscuits, Sweets, Salsa, Noodles, Snuff, Cigarettes, Cheese, Peanuts-butter
60	Processed agricultural cash crops	Sugar, Vegetable Oil, Salt, Simsim Oil, Shatta
70	Livestock and products	Live Animals, Animal Skins
80	Other manufactured consumer goods	Window Glass, Tableware, Beds, batteries, Clothing, Soaps, Shoes, Books, Tyres, Car, Paint, Stationery, Medical Goods, Carpets, Paper, Matches, Spare Parts
90	Forestry products	Firewood, Charcoal, Zaaf
100	Mining products	
110	Mineral oil products	Benzine, Fuel
120	Building and construction materials	Cement, Sand, Plaster, Timber, Zinc, Aggregate, Iron, Water pipes
130	Miscellaneous	Barrels, Carton, Tins, Iron Box, Sacks
140	Others	Water, Others

TABLE 6-14-1 COMMODITY MOVEMENT BY TRUCK, 1977

10 (Unprocessed Cereals)

(tons/day)

O \ D	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		18.4	2.9	1.0	11.7			4.2	38.2
UM RUABA	05	0.7		0.6	8.7					10.0
RAHAD	08		2.7							2.7
Rest of Project Area	02,03,04,06 07,09,10	3.2	2.4							5.6
KHARTOUM	14	1.1								1.1
PORT SUDAN	16									
West SUDAN	21,22,23,24			2.5		0.7				3.2
Rest of SUDAN	11,12,13,15,17 18,19,20,25	2.9	33.7			1.5			1.6	39.7
TOTAL		7.9	57.2	6.0	9.7	13.9			5.8	100.5

TABLE 6-14-2 COMMODITY MOVEMENT BY TRUCK, 1977

20 (Other Unprocessed Agricultural Foodstuffs)

(tons/day)

O \ D	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		2.7	1.4		2.8			0.2	7.1
UM RUABA	05	1.7		1.3	2.1			0.3		5.4
RAHAD	08	6.7	1.8						2.1	10.6
Rest of Project Area	02,03,04,06 07,09,10	0.4								0.4
KHARTOUM	14	3.3		0.6	1.2			0.6	3.0	8.7
PORT SUDAN	16									
West SUDAN	21,22,23,24					6.7				6.7
Rest of SUDAN	11,12,13,15,17 18,19,20,25	5.5			1.5				12.0	19.0
TOTAL		17.6	4.5	3.3	4.8	9.5		0.9	17.3	57.9

TABLE 6-14-3 COMMODITY MOVEMENT BY TRUCK, 1977

30 (Unprocessed Agricultural Cash Crops, Others)

(tons/day)

O \ D	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					1.9				1.9
UM RUABA	05									
RAHAD	08					1.0				1.0
Rest of Project Area	02,03,04,06 07,09,10	0.2								0.2
KHARTOUM	14									
PORT SUDAN	16									
West SUDAN	21,22,23,24									
Rest of SUDAN	11,12,13,15,17 18,19,20,25									
TOTAL		0.2				2.9				3.1

TABLE 6-14-4 COMMODITY MOVEMENT BY TRUCK, 1977

31 (Gum Arabic)

(tons/day)

O \ D	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		2.2			23.2	1.6		1.5	28.5
UM RUABA	05	0.3								0.3
RAHAD	08	0.8	1.3						1.8	3.9
Rest of Project Area	02,03,04,06 07,09,10		4.7							4.7
KHARTOUM	14	0.9								0.9
PORT SUDAN	16									
West SUDAN	21,22,23,24		0.8			2.7				3.5
Rest of SUDAN	11,12,13,15,17 18,19,20,25								0.6	0.6
TOTAL		2.0	9.0			25.9	1.6		3.9	42.4

TABLE 6-14-5 COMMODITY MOVEMENT BY TRUCK, 1977

32 (Groundnuts)

(tons/day)

O \ D	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		0.4							0.4
UM RUABA	05									
RAHAD	08									
Rest of Project Area	02,03,04,06 07,09,10									
KHARTOUM	14	0.4								0.4
PORT SUDAN	16									
West SUDAN	21,22,23,24					1.2			0.4	1.6
Rest of SUDAN	11,12,13,15,17 18,19,20,25	0.2								0.2
TOTAL		0.6	0.4			1.2			0.4	2.6

TABLE 6-14-6 COMMODITY MOVEMENT BY TRUCK, 1977

33 (Karkadeh)

(tons/day)

O \ D	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					0.4				0.4
UM RUABA	05									
RAHAD	08									
Rest of Project Area	02,03,04,06 07,09,10									
KHARTOUM	14									
PORT SUDAN	16									
West SUDAN	21,22,23,24									
Rest of SUDAN	11,12,13,15,17 18,19,20,25									
TOTAL						0.4				0.4

TABLE 6-14-7 COMMODITY MOVEMENT BY TRUCK, 1977

34 (Watermelon Seeds)

(tons/day)

O \ D	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					6.1	0.8		2.6	9.5
UM RUABA	05									
RAHAD	08									
Rest of Project Area	02,03,04,06 07,09,10									
KHARTOUM	14									
PORT SUDAN	16									
West SUDAN	21,22,23,24					7.9				7.9
Rest of SUDAN	11,12,13,15,17 18,19,20,25									
TOTAL						14.0	0.8		2.6	17.4

TABLE 6-14-8 COMMODITY MOVEMENT BY TRUCK, 1977

35 (Simsim)

(tons/day)

O \ D	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		7.4			7.0			5.4	19.8
UM RUABA	05	0.6								0.6
RAHAD	08		14.4			1.8			6.7	22.9
Rest of Project Area	02,03,04,06 07,09,10	2.0	5.9							7.9
KHARTOUM	14									
PORT SUDAN	16									
West SUDAN	21,22,23,24					0.6				0.6
Rest of SUDAN	11,12,13,15,17 18,19,20,25									
TOTAL		2.6	27.7			9.4			12.1	51.8

TABLE 6-14-9 COMMODITY MOVEMENT BY TRUCK, 1977

36 (Umbas; Feed for Animals)

(tons/day)

O \ D	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		0.5	1.2		26.9			2.0	30.6
UM RUABA	05									
RAHAD	08								0.4	0.4
Rest of Project Area	02,03,04,06 07,09,10									
KHARTOUM	14	0.4								0.4
PORT SUDAN	16									
West SUDAN	21,22,23,24					1.4				1.4
Rest of SUDAN	11,12,13,15,17 18,19,20,25								2.4	2.4
TOTAL		0.4	0.5	1.2		28.3			4.8	35.2

TABLE 6-14-10 COMMODITY MOVEMENT BY TRUCK, 1977

37 (Cotton)

(tons/day)

O \ D	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									
UM RUABA	05									
RAHAD	08									
Rest of Project Area	02,03,04,06 07,09,10									
KHARTOUM	14	0.3								0.3
PORT SUDAN	16									
West SUDAN	21,22,23,24									
Rest of SUDAN	11,12,13,15,17 18,19,20,25									
TOTAL		0.3								0.3

TABLE 6-14-11 COMMODITY MOVEMENT BY TRUCK, 1977

40 (Processed Cereal Products)

(tons/day)

O \ D	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			1.5						1.5
UM RUABA	05	0.6			1.2				0.4	2.2
RAHAD	08									
Rest of Project Area	02,03,04,06 07,09,10									
KHARTOUM	14	1.0						0.1	0.3	1.4
PORT SUDAN	16									
West SUDAN	21,22,23,24									
Rest of SUDAN	11,12,13,15,17 18,19,20,25	1.0								1.0
TOTAL		2.6		1.5	1.2			0.1	0.7	6.1

TABLE 6-14-12 COMMODITY MOVEMENT BY TRUCK, 1977

50 (Manufactured Foodstuffs)

(tons/day)

O \ D	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		0.7	1.2	0.2	4.5			3.9	10.5
UM RUABA	05	0.5								0.5
RAHAD	08									
Rest of Project Area	02,03,04,06 07,09,10									
KHARTOUM	14	18.4		1.6				9.6	2.7	32.3
PORT SUDAN	16	1.6								1.6
West SUDAN	21,22,23,24		1.3			6.7				8.0
Rest of SUDAN	11,12,13,15,17 18,19,20,25	2.7							0.6	3.3
TOTAL		23.2	2.0	2.8	0.2	11.2		9.6	7.2	56.2

TABLE 6-14-13 COMMODITY MOVEMENT BY TRUCK, 1977

60 (Processed Agricultural Cash Crops)

(tons/day)

O \ D	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		3.1	5.6	0.7	2.5			2.9	14.8
UM RUABA	05	4.9		4.8	6.4				2.2	18.3
RAHAD	08	9.2	5.4						2.4	17.0
Rest of Project Area	02,03,04,06 07,09,10									
KHARTOUM	14	21.6		2.4	0.6			27.8		52.4
PORT SUDAN	16							1.9		1.9
West SUDAN	21,22,23,24					0.4				0.4
Rest of SUDAN	11,12,13,15,17 18,19,20,25	4.9						1.3	4.5	10.7
TOTAL		40.6	8.5	12.8	7.7	2.9		31.0	12.0	115.5

TABLE 6-14-14 COMMODITY MOVEMENT BY TRUCK, 1977

70 (Livestock and Products)

(tons/day)

O \ D	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		0.3			6.6			1.1	8.0
UM RUABA	05	0.4								0.4
RAHAD	08									
Rest of Project Area	02,03,04,06 07,09,10									
KHARTOUM	14									
PORT SUDAN	16									
West SUDAN	21,22,23,24					3.2				3.2
Rest of SUDAN	11,12,13,15,17 18,19,20,25								1.2	1.2
TOTAL		0.4	0.3			9.8			2.3	12.8

TABLE 6-14-15 COMMODITY MOVEMENT BY TRUCK, 1977

80 (Other Manufactured Consumer Goods)

(tons/day)

O \ D	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		1.0	1.8	0.5	2.6			0.5	6.4
UM RUABA	05	0.7			0.1			0.3	0.6	1.7
RAHAD	08	0.6								0.6
Rest of Project Area	02,03,04,06 07,09,10									
KHARTOUM	14	31.9		2.2	0.7			10.8	3.0	48.6
PORT SUDAN	16	0.3			1.2					1.5
West SUDAN	21,22,23,24									
Rest of SUDAN	11,12,13,15,17 18,19,20,25	2.1		1.5		0.9			1.5	6.0
TOTAL		35.6	1.0	5.5	2.5	3.5		11.1	5.6	64.8

TABLE 6-14-16 COMMODITY MOVEMENT BY TRUCK, 1977

90 (Forestry Products)

(tons/day)

O \ D	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		0.1	0.2		1.2			0.3	1.8
UM RUABA	05				1.2				0.4	1.6
RAHAD	08	3.9								3.9
Rest of Project Area	02,03,04,06 07,09,10	3.8	1.6			1.2				6.6
KHARTOUM	14									
PORT SUDAN	16									
West SUDAN	21,22,23,24					1.6				1.6
Rest of SUDAN	11,12,13,15,17 18,19,20,25	1.0	1.2						4.6	6.8
TOTAL		8.7	2.9	0.2	1.2	4.0			5.3	22.3

TABLE 6-14-17 COMMODITY MOVEMENT BY TRUCK, 1977

100 (Mining Products)

(tons/day)

O \ D	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									
UM RUABA	05									
RAHAD	08									
Rest of Project Area	02,03,04,06 07,09,10									
KHARTOUM	14									
PORT SUDAN	16									
West SUDAN	21,22,23,24									
Rest of SUDAN	11,12,13,15,17 18,19,20,25									
TOTAL										0

TABLE 6-14-18 COMMODITY MOVEMENT BY TRUCK, 1977

110 (Mineral Oil Products)

(tons/day)

O \ D	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		0.1	1.8						1.9
UM RUABA	05			1.2				0.6		1.8
RAHAD	08		0.9							0.9
Rest of Project Area	02,03,04,06 07,09,10									
KHARTOUM	14	4.2			0.1			4.6		8.9
PORT SUDAN	16	4.1								4.1
West SUDAN	21,22,23,24		0.1							0.1
Rest of SUDAN	11,12,13,15,17 18,19,20,25									
TOTAL		8.3	1.1	3.0	0.1			5.2		17.7

TABLE 6-14-19 COMMODITY MOVEMENT BY TRUCK, 1977

120 (Building and Construction Materials)

(tons/day)

O \ D	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		2.7	0.5		2.8			0.7	6.7
UM RUABA	05	2.9		0.6	4.5					8.0
RAHAD	08	12.5								12.5
Rest of Project Area	02,03,04,06 07,09,10	0.2	6.4			0.9			1.3	8.8
KHARTOUM	14	7.8		0.9				3.5	1.8	14.0
PORT SUDAN	16	1.6								1.6
West SUDAN	21,22,23,24					1.9				1.9
Rest of SUDAN	11,12,13,15,17 18,19,20,25	19.3	0.9			4.0			1.9	26.1
TOTAL		44.3	10.0	2.0	4.5	9.6		3.5	5.7	79.6

TABLE 6-14-20 COMMODITY MOVEMENT BY TRUCK, 1977

130 (Miscellaneous)

(tons/day)

O \ D	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		1.0	3.3	0.2	2.9			5.3	12.7
UM RUABA	05	1.3		0.6	1.9					3.8
RAHAD	08	1.5								1.5
Rest of Project Area	02,03,04,06 07,09,10	2.4	1.5							3.9
KHARTOUM	14	5.1						0.2		5.3
PORT SUDAN	16	0.2								0.2
West SUDAN	21,22,23,24			1.5		0.3			0.5	2.3
Rest of SUDAN	11,12,13,15,17 18,19,20,25	1.2	1.5			1.0			1.0	4.7
TOTAL		11.7	4.0	5.4	2.1	4.2		0.2	6.8	34.4

TABLE 6-14-21 COMMODITY MOVEMENT BY TRUCK, 1977

140 (Others)

(tons/day)

O \ D	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		0.1	0.3	2.8	2.7			0.5	6.4
UM RUABA	05	0.1			0.4					0.5
RAHAD	08	1.2								1.2
Rest of Project Area	02,03,04,06 07,09,10	1.5								1.5
KHARTOUM	14	6.3						2.3		8.6
PORT SUDAN	16									
West SUDAN	21,22,23,24					1.3				1.3
Rest of SUDAN	11,12,13,15,17 18,19,20,25	1.1				1.8			0.3	3.2
TOTAL		10.2	0.1	0.3	3.2	5.8		2.3	0.8	22.7

TABLE 6-14-22 COMMODITY MOVEMENT BY TRUCK, 1977

TOTAL

(tons/day)

O \ D	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		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 6-15 OD TABLE OF PASSENGER MOVEMENT BY ROAD, 1977

(All types of vehicles) 1)

(Person per day)

ZONE		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL
EL OBEID	01		69.3			127.7		1.8	197.8 (41.5)	2.6	15.8	7.8	122.4	4.1	99.4 (11.0)	0.6	7.5		38.4	4.9	1.0						901.3 (52.5)
GEIFIL	02					15.0							2.4														86.7
ET TAIYARA	03																										
SHAMAGATTA	04					305.1							1.8		12.9		1.2										321.0
UM RUABA	05						82.5	38.7	170.7											55.8	34.5		0.3	5.7			836.0
ABU HAMRA	06																										82.5
SEMEIH	07														4.2												44.7
RAHAD	08											9.9	37.8		36.9								6.1				459.2 (41.5)
NAWA	09																										2.8
EL AIN	10														1.7												17.5
TENDELTI	11																			3.3	0.6		1.3				22.9
KOSTI-SENNAR	12																			1.5	112.2		1.4	1.3			280.8
WAD MEDANI	13																				10.2						14.3
KHARTOUM	14																			22.5	76.5	2.3	15.8	124.0			596.2 (11.0)
KASSALA	15																										0.6
PORT SUDAN	16																							0.6			9.3
MALAKAL	17																										
EL ABBASIYA	18																										38.4
NUBA MOUNTAIN	19																										88.0
KADUGLI-DILLING	20																										235.0
WAU-JUBA	21																										2.3
EN NAHUD	22																										24.9
NYALA	23																										131.6
BARA	24																										
ATBARA	25																										
TOTAL																											4,196.0 (105.0)

Note: 1) Figures in parentheses indicate those of bus and are included in the total figure .

TABLE 6-16 RAILWAY GOODS HANDLED AT THE FOUR STATIONS

Station	Year	Forwarded			Received			Total		
	Commodity Group	Goods Tons	Parcels Tons	Live-stock No.	Goods Tons	Parcels Tons	Live-stock No.	Goods Tons	Parcels Tons	Live-stock No.
EL OBEID	1970/71	76,575	564	67,581	139,171	2,031	-	215,746	2,595	67,581
	1971/72	77,207	448	47,795	148,973	2,422	-	226,180	2,870	47,795
	1972/73	94,089	507	43,065	110,056	2,345	9	204,145	2,852	43,074
	1973/74	68,673	413	37,629	135,104	2,224	48	203,777	2,637	37,677
	1974/75	91,308	300	22,860	98,040	3,108	420	189,348	3,408	23,280
	1975/76	66,859	2,535	32,398	147,283	7,388	1,237	214,142	9,923	33,635
RAHAD	1970/71	13,132	681	8,539	8,329	678	594	21,461	1,359	9,133
	1971/72	9,576	342	1,310	6,602	475	2,446	16,178	817	3,756
	1972/73	6,701	238	-	6,708	324	87	13,409	562	87
	1973/74	13,534	3,409	415	9,784	654	141	23,318	4,063	556
	1974/75	7,392	348	360	8,568	420	420	15,960	768	780
	1975/76	11,598	370	-	7.906	472	55	19,504	842	55
SEMEIH	1970/71	4,858	17	35	2,285	63	46	7,143	80	81
	1971/72	15,886	15	9	2,491	55	16	18,377	70	25
	1972/73	11,792	13	-	785	47	-	12,577	60	-
	1973/74	13,415	-	-	1,492	-	-	14,907	-	-
	1974/75	3,552	11	-	2,232	24	-	5,784	35	-
	1975/76	5,487	2	-	2,094	7	-	7,581	9	-
UM RUABA	1970/71	31,056	149	4,196	21,276	758	164	52,332	907	4,360
	1971/72	20,099	219	2,497	21,097	850	14	41,196	1,069	2,511
	1972/73	20,613	138	455	14,328	2,686	-	34,941	2,824	455
	1973/74	17,059	104	2,430	14,574	685	-	31,633	789	2,430
	1974/75	16,596	65	1,460	11,480	408	-	28,076	473	1,460
	1975/76	22,621	96	4,159	8,877	317	-	31,498	413	4,159
TOTAL	1970/71	125,621	1,411	80,351	171,061	3,530	804	296,682	4,941	81,155
	1971/72	122,768	1,024	51,611	179,163	3,802	2,476	301,931	4,826	54,087
	1972/73	133,195	896	43,520	131,877	5,402	96	265,072	6,298	43,616
	1973/74	112,681	3,926	40,474	160,954	3,563	189	273,635	7,489	40,663
	1974/75	118,848	724	24,680	120,320	3,860	840	239,168	4,584	25,520
	1975/76	106,565	3,003	36,557	166,160	8,184	1,292	272,725	11,187	37,894

Source: Saudan Railways Corporation, 1977

TABLE 6-17 PASSENGER BOOKINGS AT THE FOUR STATIONS

Station	Year	Class 1st	2nd	3rd	4th	Total
El Obeid	1970/71	3,894	9,594	37,364	44,107	94,959
	1971/72	3,390	7,960	30,076	53,716	95,142
	1972/73	4,307	9,337	36,030	59,574	109,248
	1973/74	4,255	8,712	33,886	43,492	90,345
	1974/75	5,979	9,660	40,556	28,114	84,309
	1975/76	6,171	9,844	36,854	39,605	92,474
Rahad	1970/71	353	1,063	5,352	44,530	51,298
	1971/72	390	977	5,565	41,198	48,130
	1972/73	476	966	5,583	37,782	44,807
	1973/74	446	933	5,747	28,577	35,703
	1974/75	324	576	4,145	23,298	28,343
	1975/75	522	1,068	5,922	23,712	31,224
Semeih	1970/71	39	122	786	9,252	10,199
	1971/72	31	63	579	7,092	7,765
	1972/73	34	122	662	6,689	7,507
	1973/74	79	126	607	4,600	5,412
	1974/75	34	68	494	3,432	4,028
	1975/76	60	122	362	2,634	3,168
Um Ruaba	1970/71	666	1,772	7,243	46,585	56,266
	1971/72	692	1,658	6,291	45,190	53,831
	1972/73	938	1,621	7,256	38,322	48,137
	1973/74	884	1,558	6,533	27,869	36,844
	1974/75	646	1,128	5,630	23,366	30,770
	1975/76	637	883	6,317	25,490	33,327
TOTAL	1970/71	4,952	12,551	50,745	144,474	212,722
	1971/72	4,503	10,658	42,511	147,196	204,868
	1972/73	5,755	12,046	49,531	142,367	209,699
	1973/74	5,664	11,329	46,773	104,538	168,304
	1974/75	6,983	11,432	50,825	78,210	147,450
	1975/76	7,390	11,907	49,455	91,441	160,193

Source: Ibid

ANNEX VI-20 ESTIMATION OF ORIGIN AND DESTINATION OF RAILWAY PASSENGERS

20.1 Railway Passengers Interviewed

The characteristics of railway passengers interviewed during the field survey are explained in CHAPTER VI of the main text, and summarized in the following Table 6-18-1. As shown in the table, all major types of trains operating in the area are included in the survey. Based on the number of interviewed passengers in Table 6-18-1, the daily number of passengers is estimated as in the following sections, 20.2 and 20.3.

ANNEX VI-20

TABLE 6-18-1 RAILWAY PASSENGERS INTERVIEWED

Date	Direction	Type of Train	Number of Passengers Interviewed	Capacity of Train (seats)	Ramarks (Service times/week)
May 17	El Obeid → Khartoum	Express	1,175	961	2
20	Khartoum → El Obeid	- " -	713	961	2
18	Khartoum → El Obeid	Normal	731	758	5
19	El Obeid → Khartoum	- " -	834	758	5
21	El Obeid → Khartoum	- " -	380	758	5
19	Nyala → Khartoum	- " -	1,035	758	4 1)
20	Khartoum → Nyala	Express	722	961	3 1)

Note: 1) Same number of trains are served for the opposite direction.

20.2 Estimation of OD Pattern of Railway Passengers

The distribution of the origin and destination of railway passengers reulting from the interview survey differs according to the type of train. In order to estimate the overall OD pattern of railway passengers of all trains in the section between El Obeid and Um Ruaba, OD traffic of each train was weighted according to capacity and frequency of services of each type of train assuming a constant occupancy rate. Capacities and operating frequencies of trains are shown in Table 6-18-1 and capacities of trains were estimated as shown in Table 6-19.

20.3 Estimation of OD Traffic of Railway Passengers

OD traffic of railway passengers, in terms of ADT, was estimated from the OD pattern of railway passengers and the actual number of railway passengers recorded at El Obeid, Rahad and Semeih stations. The total column of Table 6-18-2 contains the actual number of railway passengers of these three stations, and the figures in the other column were obtained by conversion calculation according to the OD pattern.

TABLE 6-18-2 OD TABLE OF RAILWAY PASSENGER

(Persons per day)

ZONE		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL
EL OBEID	01					53.6	0.3	1.2	3.4			7.0	108.1	43.7	303.9	9.2	5.2	0.5				0.6		1.3		8.1	552.1
GEIFIL	02																										
ET TAIYARA	03																										
SHAMAGATTA	04																										
UM RUABA	05							1.9	51.1													3.7	4.3	5.2			125.8
ABU HAMRA	06												2.0	0.9	1.1												4.3
SEMEIH	07											9.9	2.6		0.3		2.6										18.5
RAHAD	08											7.5	38.7	18.7	72.4	1.7	0.7									3.5	197.7
NAWA	09												0.3	0.2													0.5
EL AIN	10												0.9		0.9												1.8
TENDELTI	11																						0.7	6.0			31.1
KOSTI-SENNAR	12																						6.7	98.9	1.6		259.8
WAD MEDANI	13																					1.7	9.1	75.4	0.9		150.6
KHARTOUM	14																			0.3	3.7	2.6	27.9	46.9	2.0		662.0
KASSALA	15																			0.2	0.6		0.9	7.6			20.2
PORT SUDAN	16																				0.7		0.4	3.2			12.8
MALAKAL	17																							0.7			1.2
EL ABBASIYA	18																										
NUBA MOUNTAIN	19																										0.5
KADUGLI-DILLING	20																										5.0
WAU-JUBA	21																										8.6
EN NAHUD	22																									2.6	52.6
NYALA	23																									0.9	446.1
BARA	24																									1.3	5.8
ATBARA	25																										16.4
TOTAL																											2,573.4

TABLE 6-19 ESTIMATE OF TRAIN CAPACITY

Train Type / Class	Express		Normal		Local	
	No. of Coaches	Capactiy (seats)	No. of Coaches	Capacity (seats)	No. of Coaches	Capacity (seats)
Sleeper	2	26	1	13	0	-
1st Class	2	64	1	32	1	16
2nd Class	2	96	1	48	1	24
3rd Class	3	225	3	225	1	75
4th Class	5	550	4	440	1	110
Buffet	1	-	0	-	0	-
Luggage	1	-	1	-	0	-
Brake Wagon	1	-	0	-	0	-
Total	17	961	11	758	4	225

Source: Interview at El Obeid Station.

ANNEX VI-21 ESTIMATION OF VEHICLE OPERATING COST

21.1 Operating Characteristics of Representative Vehicles

Representative vehicles chosen for estimating operating costs are Toyota Corolla 1200 for cars, Toyota Land Cruiser pick up for vans/pick-ups, Bedford 6-ton truck for medium trucks, Fiat 682 11-ton truck for heavy trucks and remodelled Bedford 6-ton truck for buses.

The operating characteristics of these vehicles are summarized in Tables 6-20-1 to 6-20-4. Average running speed, annual kilometrage, vehicle life kilometrage and average operating hours per annum are related to each other, and are decided on the basis of an analysis of the results of the field survey, interviews and the driving survey conducted in the area.

21.2 Depreciation and Interest of Vehicles, etc.

i) Prices of vehicles, tyres and locally manufactured bodies

Prices of vehicles were obtained from an analysis of the interview results and various shipping documents provided by dealers in the area, and the results are shown in Table 6-20-5. Financial cost is the market price of the vehicle and economic cost is the cost after taxes, such as import duties, development tax, bank exchange tax, etc., are deducted. The economic cost is composed of the local currency component (transportation in the country, handling charges, commissions, etc.) and the foreign exchange component.

TABLE 6-20-1 AVERAGE RUNNING SPEED

(km/hr)

Road Surface	Vehicle Type	Car	Van Pick-up	Medium Truck	Heavy Truck	Bus
Paved Road		85	75	60	60	60
Gravel Road		70	65	52	52	52
Hard Surface Track		60	55	45	43	45
Loose Sand Track		-	35	28	25	28

TABLE 6-20-2 ANNUAL KILOMETRAGE

(000 km)

Road Surface	Vehicle Type	Car	Van Pick-up	Medium Truck	Heavy Truck	Bus
Paved Road		20.00	31.25	70.00	75.00	84.00
Gravel Road		16.00	27.50	60.00	63.33	72.00
Hard Surface Track		12.00	22.50	52.00	55.00	62.00
Loose Sand Track		-	18.75	33.33	35.00	40.00

TABLE 6-20-3 VEHICLE LIFE KILOMETRAGE

(000 km)

Road Surface	Vehicle Type	Car	Van Pick-up	Medium Truck	Heavy Truck	Bus
Paved Road		200	250	420	450	420
Gravel Road		160	220	360	380	360
Hard Surface Track		120	180	310	330	310
Loose Sand Track		-	150	200	210	200

TABLE 6-20-4 AVERAGE OPERATING HOURS PER ANNUM

(hours/year)

Road Surface	Vehicle Type	Car	Van Pick-up	Medium Truck	Heavy Truck	Bus
Paved Road		-	-	1,170	1,250	1,400
Gravel Road		-	-	1,150	1,220	1,380
Hard Surface Track		-	-	1,160	1,280	1,380
Loose Sand Track		-	-	1,190	1,400	1,430

The residual value of vehicles was estimated from interviews in the area. Table 6-20-6 shows the price of a set of tyres. The most popular tyre type was selected for the analysis.

TABLE 6-20-5 PRICE OF REPRESENTATIVE VEHICLE, 1977 1) (LS)

Vehicle Type	Foreign Exchange	Local Component	Economic	Taxes & Duties	Financial	Salvage Value (%)
Car (Toyota Corolla)	1,170	933	2,103	2,146	4,249	15
Van/Pick-up (Toyota Pick-up)	2,487	1,126	3,613	1,897	5,510	15
Medium Truck 2) (Bedford)	3,541	1,326	4,867	1,533	6,400	30
Heavy Truck (Fiat 682)	11,312	1,542	12,854	6,374	19,228	30
Bus 2) (Bedford)	3,541	1,326	4,867	1,533	6,400	30

Source: Interviews with dealers.

Notes: 1) Including tyres

2) Excluding the prices of locally manufactured bodies. They are shown in Table 6-20-7.

TABLE 6-20-6 PRICE OF A SET OF TYRES, 1977

Vehicle Type	Type of Tyre Used	Price (LS) Financial	Price (LS) Economic	Number of Tyres
Car,	600-12-4PR	70.000	49.996	4
Van/pick-up	750-16-8PR	200.000	139.984	4
Medium Truck	Front: 900-20-12PR Rear :1200-20-16PR	181.400 353.400	126.966 227.368	4
Heavy Truck	1200-20-16PR	1,060.200	742.062	6
Bus	Front: 900-20-12PR Rear :1200-20-16PR	181.400 353.400	126.966 227.368	4

Source: Interviews with dealers

Bodies of buses and medium trucks are usually manufactured in the Sudan. Although types and structures of bodies vary, prices shown in Table 6-20-7 are considered to indicate the average price.

TABLE 6-20-7 PRICE OF LOCALLY MANUFACTURED BODY, 1977

(LS)

	Financial	Economic
Medium Truck	1,500	1,095
Bus	2,500	1,825

Source: Interviews with dealers

ii) Depreciation and interest

Depreciation and interest of vehicles is calculated by the following formula.

$$D = (C - R) \times \frac{i (1 + i)^n}{(1 + i)^n - 1} \times \frac{n}{LM}$$

where; D = depreciation and interest cost (mm/km)

C = vehicle price excluding that of tyres (LS)

R = residual value of vehicle (LS)

i = interest rate (10 percent)

n = life years of vehicle (year)

LM = life kilometrage of vehicle (km)

iii) Insurance fees

Insurance fees vary by type of vehicle. Table 6-20-8 shows the results obtained from interviews with an insurance company in the Sudan.

TABLE 6-20-8 INSURANCE FEES

Type of Vehicle	Financial (LS)	Economic (LS)	Basis of Calculation
Car	147.5	125.3	On the first LS 1,000 5%, on the balance 3% of the total price of the vehicle
Van/Pick-up	185.3	157.5	
Medium Truck	192.0	163.2	3% of the total price of the vehicle
Heavy Truck	576.8	490.3	
Bus	222.0	188.7	On the first LS 1,000 6%, on the balance 3% of the total price of the vehicle. Not insurable for passengers

Source: Blue Nile Insurance Company, Sudan

iv) Wages of drivers and assistants

Trucks are usually operated in the area by a driver and two assistants. Table 6-20-9 shows the average wages obtained from interviews with drivers and trucking companies in the area.

The economic cost of wages was estimated after deducting income taxes from the wages. Table 6-20-10 shows the income tax rate.

TABLE 6-20-9 AVERAGE MONTHLY WAGES OF DRIVERS AND ASSISTANTS 1)

(LS/month)

	Driver	Assistant I	Assistant II
Medium Truck	65	23	12
Heavy Truck	65	23	12
Bus	70	23	12

Source: Interviews with drivers and transport companies.
Note : 1) Wages include salaries and monetary fringe benefits.

TABLE 6-20-10 TAXATION (INCOME TAX) FOR RESIDENTS

(per year)

	On the first	Following							More than
Income (LS)	400	200	400	1,000	1,000	2,000	2,000	2,000	9,000
Percent	0	5	10	15	20	30	40	50	60

Source: Ministry of National Planning

v) Licensing fees

Table 6-20-11 shows the amount of licensing fees, town development fees and service fees which must be paid annually by vehicle owners.

TABLE 6-20-11 ANNUAL LICENSE FEES BY VEHICLE TYPE, 1977

(LS)

Vehicle Type	Licensing Fees	Town Development Fees	Service Fees	Total
Car	8	1	2	11
Van/Pick-up	9	1	2	12
Medium Truck	23	3	2	28
Heavy Truck	23	3	10	36
Bus	23	3	2	28

Source: Kordofan Province Authorities and El Obeid Municipal Council.

vi) Fuel consumption

Fuel consumption was surveyed during the interviews because it was thought that an estimate of fuel consumption under the road conditions in the area would be quite difficult. In estimating the fuel consumption for road surfaces of loose sand and hard surface clay, results of the interviews were usually used together with those of the driving survey by Toyota pick-ups. Estimation of fuel consumption on gravel and paved roads is based on the driving survey in the area as well as the various literature and data such as "Quantification of Road User Savings, IBRD". Table 6-20-12 shows the results of this analysis.

TABLE 6-20-12 FUEL CONSUMPTION

(liters per 1,000 km)

Road Surface	Vehicle Type: Car	Van Pick-up	Medium Truck	Heavy Truck	Bus
Paved	80	200	250	300	250
Gravel	100	250	300	390	300
Hard Surface	120	300	375	480	375
Loose Sand	-	450	600	900	600

Price of fuel was surveyed at both Khartoum and El Obeid and the average price is used for the analysis.

TABLE 6-20-13 PRICE OF FUEL IN KHARTOUM AND EL OBEID AREAS

LS/Gallon
(LS/liter)

	With Tax	Without Tax
Benzine (Gasoline)	0.460 (0.1012)	0.240 (0.0528)
Gasoline (Diesel)	0.368 (0.0810)	0.312 (0.0686)

Source: Shell Oil Company, Sudan

vii) Oil consumption

Oil consumption was estimated, as shown in Table 6-20-14, from the results of the field survey and "Quantification of Road User Savings, IBRD". Table 6-20-15 shows the price of engine oil.

TABLE 6-20-14 OIL CONSUMPTION

(liters per 1,000 km)

	Vehicle Type				
Road Surface	Car	Van Pick-up	Medium Truck	Heavy Truck	Bus
Paved	1.1	1.4	2.3	6.8	2.3
Gravel	1.3	1.6	2.6	7.8	2.6
Hard Surface	1.6	1.9	3.1	9.4	3.1
Loose Sand	-	2.5	4.0	12.2	4.0

TABLE 6-20-15 PRICE OF ENGINE OIL

LS/Gallon
(LS/Liter)

	With Tax	Without Tax
For Gasoline Engine	2.350 (0.517)	2.039 (0.449)
For Diesel Engine	1.855 (0.408)	1.589 (0.350)

Source: Shell Oil Company, Sudan

viii) Tyre wear

Tyre wear varies depending on the surface conditions of the roads. For hard surface clay and loose sand roads information was obtained from drivers and garage operators in the area, whilst "Quantification of Road User Savings, IBRD" was referred to for the other road surfaces. Table 6-20-16 shows the life time of a set of tyres on different road surfaces. Prices of tyres are shown in Table 6-20-6.

TABLE 6-20-16 TYRE WEAR

('000 km)

	Vehicle Type				
Road Surface	Car	Van Pick-up	Medium Truck	Heavy Truck	Bus
Paved	30	38	45	45	45
Gravel	15	18	23	23	23
Hard Surface	9	10	12	12	12
Loose Sand	-	12	14	14	14

ix) Maintenance

High maintenance costs are required under the particular road conditions in the area. In order to maintain a vehicle in good condition, owners must spend more than LS 2,000 per annum after 2 or 3 years' usage of a medium-size truck.

Tables 6-20-17 and 6-20-18 show the maintenance cost of parts and labour, as an analysis of information obtained from extensive interviews with dealers and garage operators in the area as well as from other feasibility reports and other literature.

TABLE 6-20-17 MAINTENANCE: PARTS

(% of depreciable value/1,000 km)

	Vehicle Type				
Road Surface	Car	Van Pick-up	Medium Truck	Heavy Truck	Bus
Paved	0.13	0.14	0.13	0.12	0.13
Gravel	0.16	0.20	0.19	0.18	0.19
Hard Surface	0.45	0.50	0.50	0.47	0.50
Loose Sand	-	0.78	0.78	0.73	0.78

TABLE 6-20-18 MAINTENANCE: HOURS OF LABOUR

(hours/1,000 km)

	Vehicle Type				
Road Surface	Car	Van Pick-up	Medium Truck	Heavy Truck	Bus
Paved	0.75	0.9	3.0	3.5	3.0
Gravel	1.0	1.3	4.9	5.7	4.9
Hard Surface	2.0	2.6	9.8	11.4	9.8
Loose Sand	-	3.6	13.7	16.0	13.7

x) Overhead

Overhead cost is assumed to be 10% of the total cost for commercial vehicles.

xi) Adjustment of vehicle operating cost due to changes in road gradient

The operating cost of a vehicle is affected by changes in road gradient. Although many cost factors are affected, only the effect on fuel consumption is considered because the influence of a gradient change on other factors is negligible and most of the road sections in the area of the study are flat. Table 6-20-19 shows the results of the analysis which is based mainly on "Quantification of Road User Savings,IBRD". Gradient between 0 and 3 percent are regarded as flat.

TABLE 6-20-19 PERCENTAGE INCREASE OF FUEL CONSUMPTION DUE TO A CHANGE IN ROAD GRADIENT

(%)

Gradient	Car	Van/Pick-up	Truck, Bus
0 - 3%	100	100	100
3 - 5%	110	124	143

xii) Vehicle operating cost during the rainy season

Heavy rainfall in the area during the rainy season affects vehicle operating cost on roads of hard surface clay and loose sand.

Particularly, tracks of hard surface clay are affected by rain to such an extent that they become muddy and vehicles often find it difficult to run. In the case of loose sand, the surface becomes firmer with rainfall and driving conditions improve but, on the other hand, tracks are often cut off by streams in qoz areas. Therefore, vehicles must wait at riversides or detour around them.

Although it is very difficult to estimate the influence of rainfall accurately, it has been estimated that, for hard surface clay roads, vehicle operating costs during the rainy season (June to September) are 50 percent higher than during the dry season, while operating costs do not change for loose sand roads.

ANNEX VII

TABLE 7-1 TRAFFIC ON PROPOSED ROAD, 1977[1)]

(Vehicles per day)

	Section						
	01 - 10	10 -09	09-08	08-07	07-06	06-05	Average
	Distance[2)] (Km)						
Type of Vehicle	23.5	23.5	21.0	20.0	25.0	21.6	134.6
Small Vehicles	7.2	5.8	5.6	4.1	3.7	3.7	5.0
Medium Trucks	109.9	109.7	108.9	121.0	130.8	134.7	119.2
Large Trucks	4.4	4.4	4.4	4.9	4.5	4.5	4.5
Buses	1.5	1.5	1.5	0.2	0.2	0.2	0.9
Total	123.0	121.4	120.4	130.2	139.2	143.1	129.6

Notes: 1) Normal Traffic is quoted in 9.03, CHAPTER IX.
Neither diverted nor generated traffic is included.

2) This section is between RAHAD and SEMEIH.

TABLE 7-2 TRAFFIC AND STANDARD AXLE NUMBERS ESTIMATED: RAHAD - SEMEIH

(Vehicles/day)

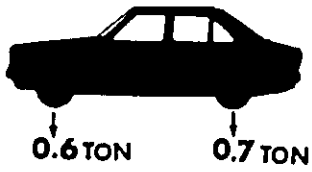
		Growth Rate per Year		Traffic: Trucks Medium Truck	Trucks Large Truck	Trucks Total	Buses	Small Vehicles	Total
	1977		Feasibility	120.9	5.0	125.9	0.2	4.1	130.2
1	78		Detailed	128.0	6.7	134.7	0.2	4.4	139.3
2	79		Design	135.5	8.6	144.1	0.2	4.7	149.0
3	80			141.9	12.3	154.2	0.2	5.0	159.4
4	81		Construction	150.1	14.9	165.0	0.3	5.4	170.7
5	82			158.9	17.7	176.6	0.3	5.8	182.7
6	83		Open 1st Year	166.2	22.7	188.9	0.3	6.2	195.4
7	84	7%	2	173.9	28.3	202.2	0.3	6.6	209.1
8	85		3	181.7	34.6	216.3	0.3	7.0	223.6
9	86		4	189.8	41.7	231.5	0.4	7.5	239.4
10	87		5	200.6	47.1	247.7	0.4	8.1	256.2
11	88		6	209.3	55.7	265.0	0.4	8.6	274.0
12	89		7	221.2	62.4	283.6	0.5	9.2	293.3
13	90		8	230.6	72.8	303.4	0.5	9.9	313.8
14	91		9	243.4	81.2	324.6	0.5	10.6	335.7
15	92	-----	10	253.6	93.8	347.4	0.6	11.3	359.3
16	93		11	262.6	102.1	364.7	0.6	11.9	377.2
17	94		12	271.9	111.1	383.0	0.6	12.5	396.1
18	95		13	277.4	124.7	402.1	0.6	13.1	415.8
19	96		14	287.1	135.1	422.2	0.7	13.7	436.6
20	97		15	297.0	146.3	443.3	0.7	14.4	458.4
21	98	5%	16	302.6	162.9	465.5	0.7	15.2	481.4
22	99		17	312.8	176.0	488.8	0.8	15.9	505.5
23	2000		18	323.2	190.0	513.2	0.8	16.7	530.7
24	1		19	328.7	210.1	538.8	0.9	17.5	557.2
25	2		20th Year	339.5	226.3	565.8	0.9	18.4	585.1
A			Total	5,073.2	2,124.8	7,198.0	11.5	234.3	7,443.8
B	Accumulated Traffic Volume over 20 Years, A x 365			1,851,718	775,552	2,627,270	4,198	85,520	2,716,988
C	Equivalent Factors of a Standard Axle Number			0.3533	2.6906	-	0.0614	0.0036	-
D	Total Accumulated Standard Axle Numbers B x C			654,212	2,086,390	2,740,602	258	308	2,714,168
E	Diverted Traffic and Others D x 10%			65,421	208,639	274,060	26	31	274,117
F	Total Accumulated Standard Axle Numbers D + E			719,633	2,295,029	3,014,662	284	339	3,015,285
G	Accumulated Standard Axle Numbers on One Side of Carriageway			359,817	1,147,514	1,507,331	142	170	1,507,643

FIG. 7-1

AXLE LOAD OF REPRESENTATIVE VEHICLE

Equivalent Standard Axles

SALOON CAR : TOYOTA COROLLA



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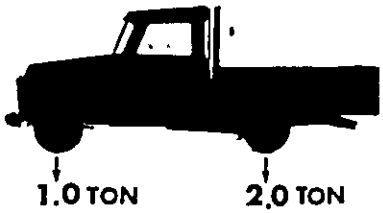
FOUR WHEEL DRIVE VAN & PICK-UP : TOYOTA LANDCRUISER PICK-UP



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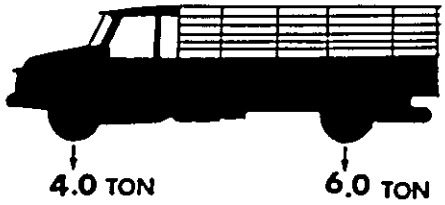
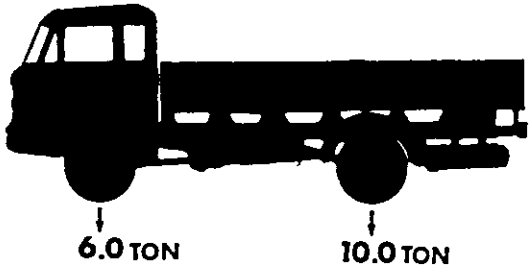
TRUCK 6-TON LOADING CAPACITY : BEDFORD



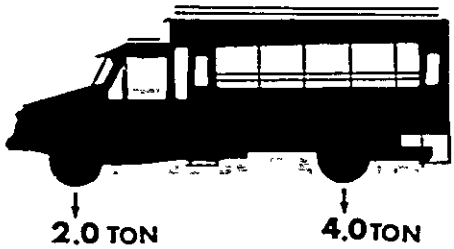
(0.0578 + 0.2955)

HEAVY TRUCK 11-TON LOADING CAPACITY : FIAT 682



(0.2955 + 2.3951)

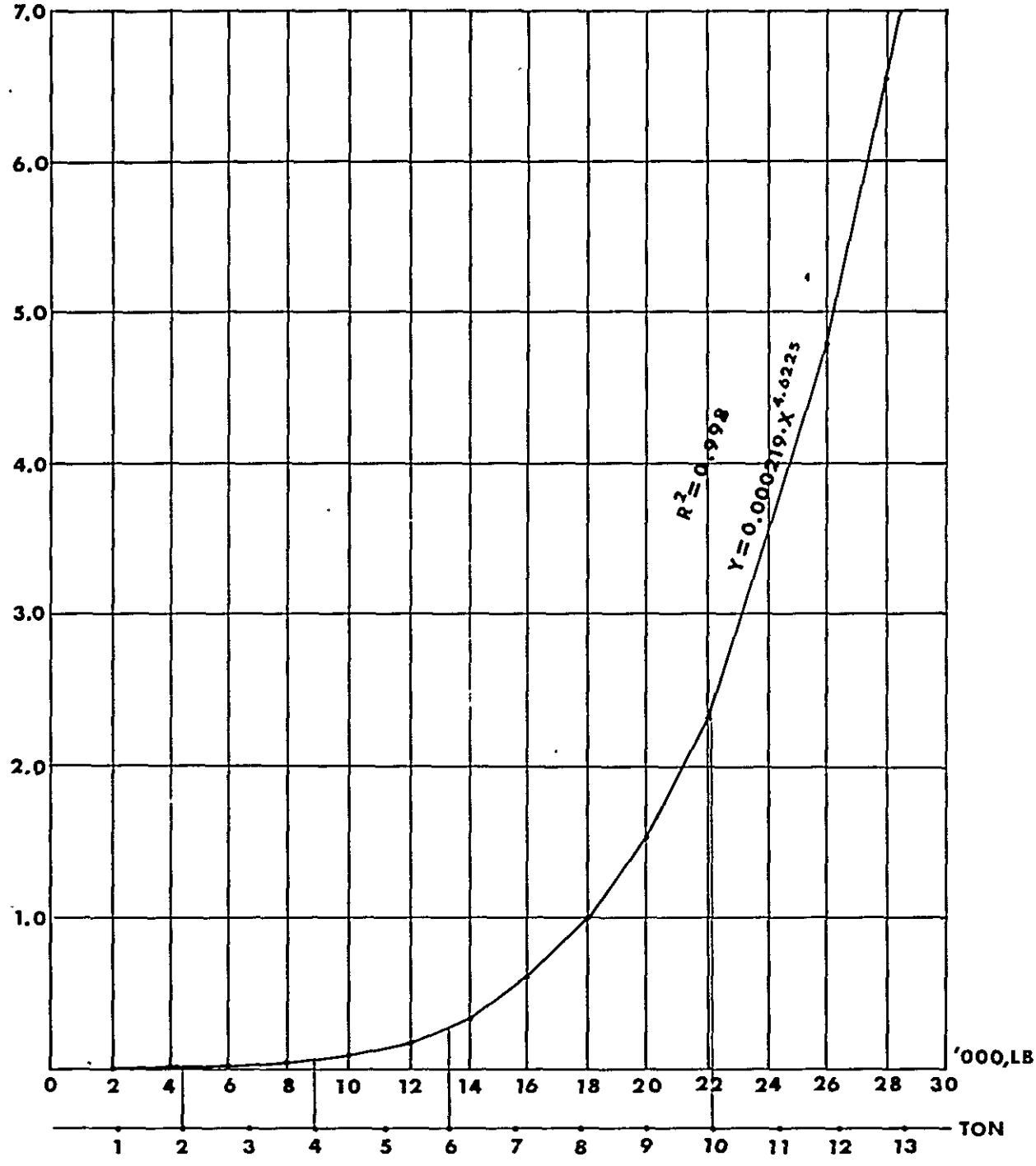
BUS 44-PASSENGER : BEDFORD



(0.0036 + 0.0578)

FIG. 7-2 EQUIVALENCE FACTORS FOR VARIOUS AXLE LOADING.

FLEXIBLE PAVEMENT : PT=2.0 SN= 3



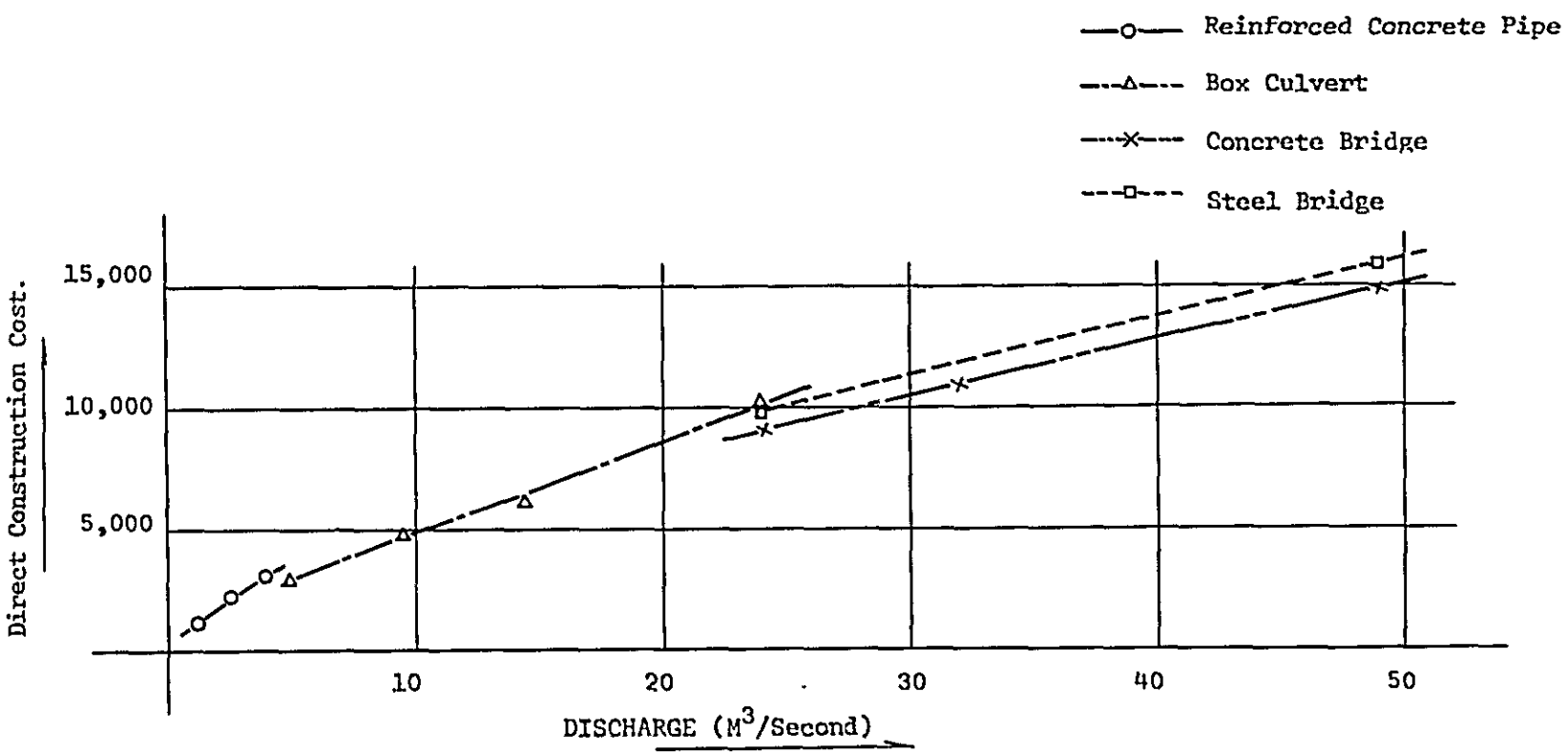
SOURCE : AASHTO INTERIM GUIDE FOR DESIGN OF PAVEMENT STRUCTURE 1972

TABLE 7-3 RELATIONSHIP BETWEEN ALLOWABLE DISCHARGE AND THE COST OF STRUCTURE

		Discharge (M^3/Second)	Construction Cost (LS)
PIPE CULVERT	Ø1000 x 1	1.26	1,198
	Ø1000 x 2	2.52	2,167
	Ø1000 x 3	3.78	3,028
BOX CULVERT H. V. (2.0 x 1.5)	1 Cell	4.8	2,999
	2 Cells	9.6	4,738
	3 Cells	14.4	6,255
	4 Cells	24.0	11,000
BRIDGE (CONCRETE)	L=7.0M (1 span)	24.0	9,100
	L=9.0M (1 span)	32	10,744
	L=7.0Mx2 (2 spans)	49	15,037
	L=9.0Mx2 (2 spans)	65	18,384
	L=9.0Mx3 (3 spans)	98	26,021
BRIDGE (STEEL)	L=7.0 (1 span)	24	9,760
	L=14.0 (2 spans)	49	16,100

Note: Comparison in direct construction cost.

FIG. 7-3 RELATIONSHIP BETWEEN DISCHARGE AND THE COST OF STRUCTURES 1)

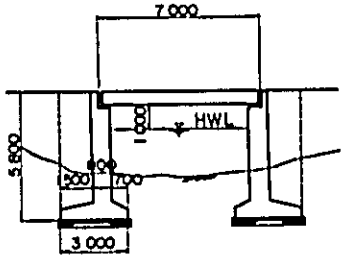


Note: 1) Produced from Table 7-3 in Annex VII-5.

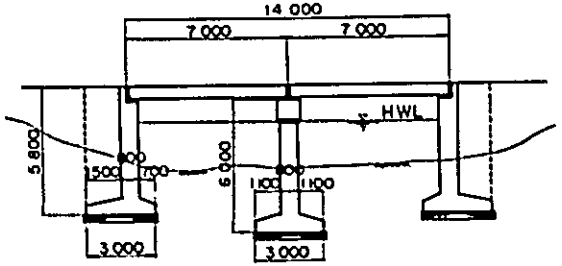
FIG VII - 4 TYPE OF BRIDGE

PROFILE S = 1:100

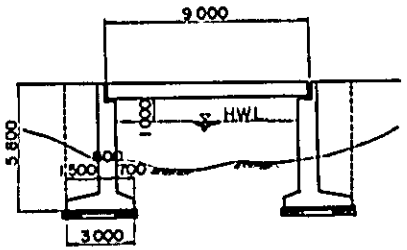
TYPE 1



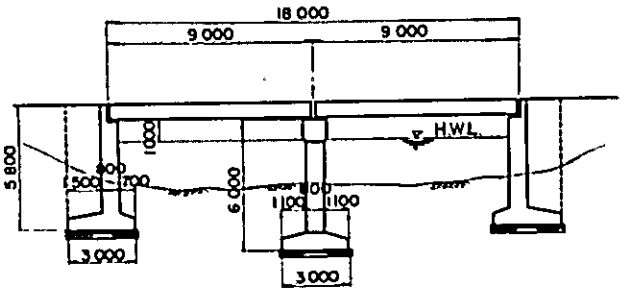
TYPE 3



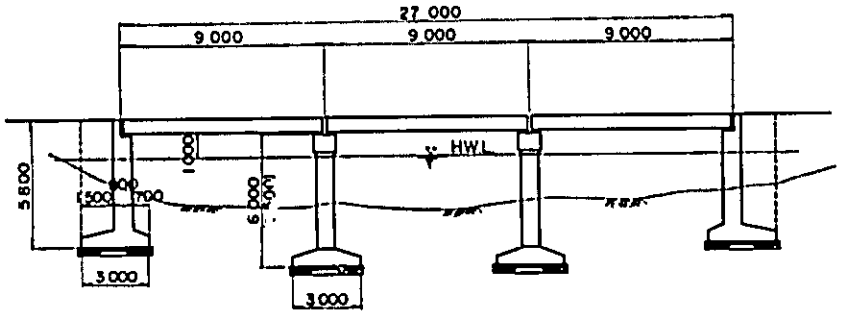
TYPE 2



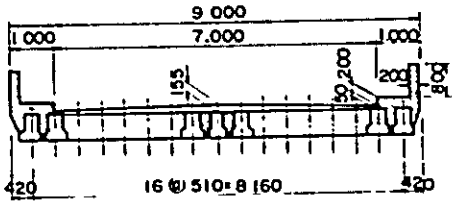
TYPE 4



TYPE 5



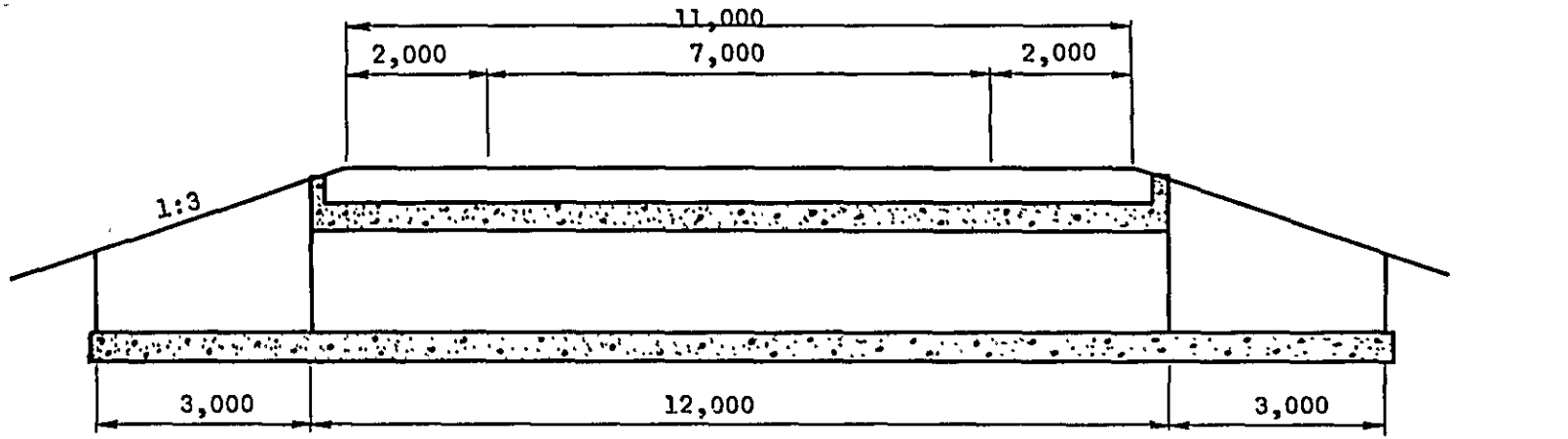
TYPICAL CROSS SECTION S = 1.50

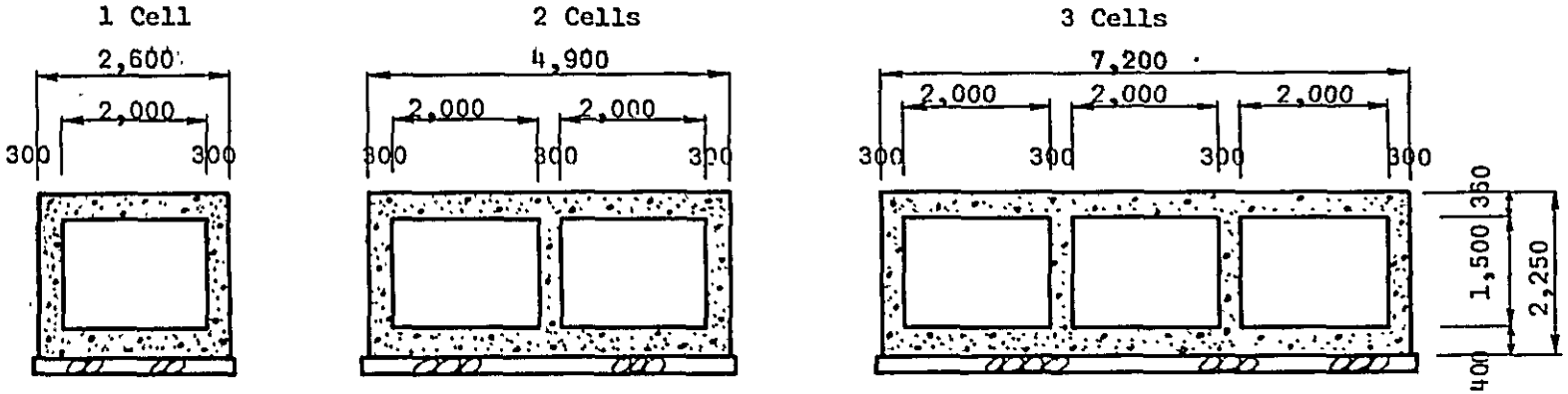


Note :

1. TYPE 1 ; L = 7.0 M (1 span)
2. TYPE 2 ; L = 9.0 M (1 span)
3. TYPE 3 ; L = 7.0 M X 2 (2 spans)
4. TYPE 4 ; L = 9.0 M X 2 (2 spans)
5. TYPE 5 ; L = 9.0 M X 3 (3 spans)

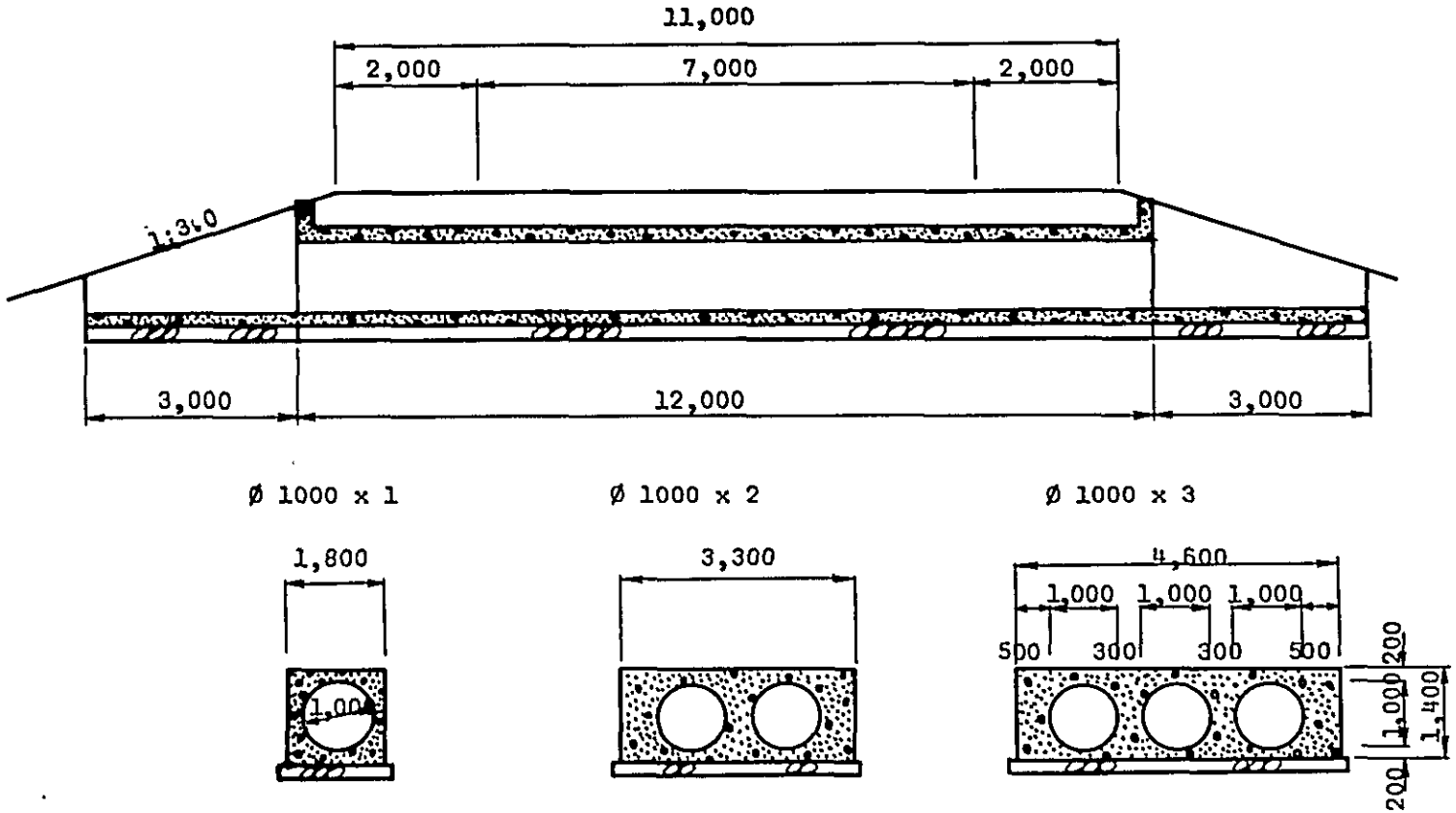
FIG. 7-5 TYPE OF BOX CULVERT





Note: Reinforced Concrete

FIG. 7-6 TYPE OF PIPE CULVERT



Note : Refer to Drawings.

TABLE 7-4 BRIDGE STATION, BRIDGE LENGTH AND ESTIMATED DISCHARGE

No.	Route	Station	Discharge	Bridge Length
1	A	6k + 430km	27.7 t/sec	L=9.0m
2	A	12 + 440	33.0	L=9.0
3	A	12 + 730	29.3	L=9.0
4	A	21 + 550	83.6	L=27.0 (9.0x3span)
5	A	22 + 950	78.5	L=27.0 (9.0x3span)
6	A	27 + 120	32.6	L=9.0
7	A	30 + 600	47.2	L=14.0 (7.0x2span)
8	A	45 + 300	30.3	L=9.0
9	A	51 + 900	39.5	L=14.0 (7.0x2span)
10	A	55 + 900	51.6	L=18.0 (9.0x2span)
11	B	13 + 400	67.7	L=27.0 (9.0x3span)
12	B	14 + 300	23.9	L=7.0
13	B	17 + 200	22.9	L=7.0
14	B	20 + 700	76.4	L=27.0 (9.0x3span)
15	B	23 + 900	42.2	L=14.0 (7.0x2span)
16	B	27 + 800	119.4	L=27.0 (9.0x3span)
17	B	28 + 700	22.9	L=7.0
18	B	29 + 550	43.2	L=14.0 (7.0x2span)
19	B	35 + 750	37.1	L=14.0 (7.0x2span)
20	B	36 + 000	53.8	L=18.0 (9.0x2span)
21	B	50 + 600	18.0	L=7.0
22	F	4 + 640	38.6	L=14.0 (7.0x2span)
23	F	7 + 750	56.6	L=14.0 (7.0x2span)
24	F	10 + 000	41.1	L=14.0 (7.0x2span)
25	C	15 + 500	21.8	L=7.0
26	C	18 + 450	17.6	L=7.0
27	C	18 + 900	19.6	L=7.0
28	D	12 + 900	21.8	L=7.0
29	D	15 + 900	17.6	L=7.0
30	D	17 + 700	19.6	L=7.0

TABLE 7-5-1 COMPARISON OF CONSTRUCTION COST: FLAT SLAB BRIDGE, BEAM AND SLAB BRIDGE AND T-BEAM BRIDGE

L = 7.0 m
(LS in Economic Cost)

Item	Flat Slab Bridge	Beam and Slab Bridge	T-Beam Bridge
Precast Beam	-	3,009	-
Concrete A	1,287	-	885
Concrete B	-	175	-
Reinforcement	1,505	125	1,329
Form Work	312	25	678
Scaffolding	360	-	490
Asphalt Pavement	123	123	123
SUBSTRUCTURE	5,602	5,602	5,602
Total	9,189	9,059	9,107

TABLE 7-5-2 COMPARISON OF CONSTRUCTION COST: REINFORCED CONCRETE PIER, BRICK FRAMED PIER AND STONE FRAMED PIER

(LS in Economic Cost)

Item	Reinforced Concrete	Brick	Stone
Concrete B	1,308	-	-
Concrete C	-	1,705	1,916
Reinforcement	401	-	-
Form Work 1)	210	-	-
Scaffolding	288	684	522
Brick Work	-	825	-
Stone Work	-	-	89
FOUNDATION	85	85	85
Total	2,292	3,299	2,612

Note:1) Form work is composed of using steel pannels. A steel pannel is w 300 m/m x L 1800 m/m with 16.9 kg per sheet.

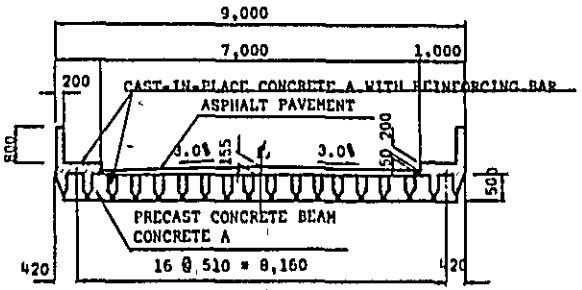
Breakdown of Price

(in LS per m^2)

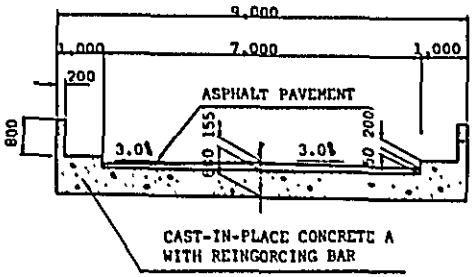
Steel Form 1.9 sheets/m^2	Foreign Component 5.01	Local Component 3.37	Tax Component 3.02	Total 11.04
6 times for use	0.84	0.56	0.50	1.90
maintenance 15%	0.13	0.08	0.08	0.29
per m^2	0.97	0.64	0.58	2.19
Economic 1.61				

FIG. 7-7 COMPARISON OF SUPERSTRUCTURE (Span Length = 7.0 m)

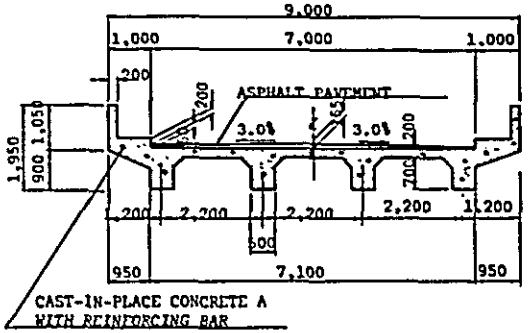
BEAM AND SLAB BRIDGE



FLAT SLAB BRIDGE



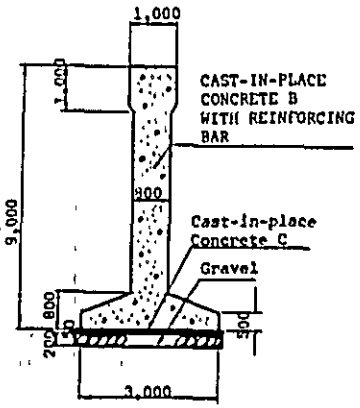
T-BEAM BRIDGE



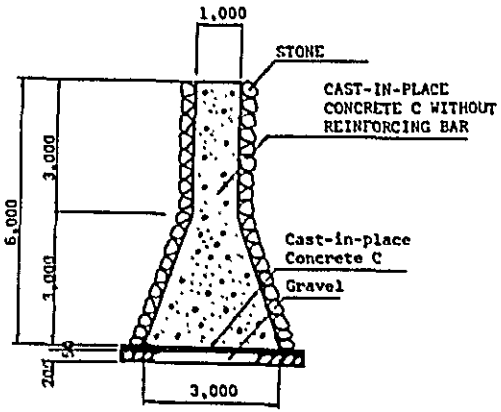
VII-12

FIG. 7-8 COMPARISON OF SUBSTRUCTURE (PIER) WIDTH = 9.0 m

REINFORCED CONCRETE



STONE FRAMED



BRICK FRAMED

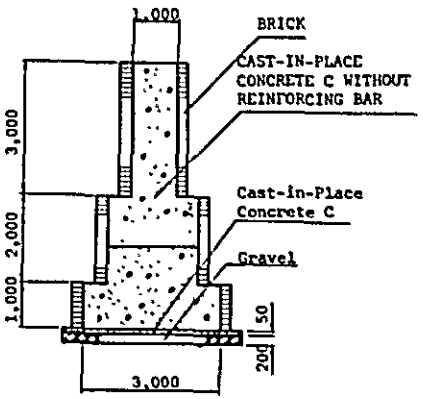


TABLE 7-6 COMPARISON OF CONSTRUCTION COST BETWEEN CORRUGATED METAL PIPE AND REINFORCED CONCRETE PIPE

Item	Corrugated Metal Pipe ø 1000 x 1 (L=20) (LS)	(Per Place) Reinforced Concrete Pipe ø 1000 x 1 (L=12.0) (LS)
Pipe	687.6	432.3
Excavation	18.4	5.4
Sand Base	21.3	-
Placing	183.0	-
Covering	212.3	-
Masonry	84.6	-
Concrete B	-	520.3
Form Work	-	67
Reinforcing Bar	-	155
Gravel	-	17.8
Total in Economic Cost	1,207.2	1,198.3

ANNEX VII-13 ACQUISITION COST

13.1 Mechanical Equipment

Prices for mechanical equipment were obtained from equipment suppliers. Annex VIII-12 shows the cost of acquisition of equipment and daily rate as a percent of acquisition cost and details of D7G of Caterpiller Co., as an example.

13.2 Labour

The following labour costs are estimated on the basis of RBPC of Sudan and El Obeid City standard which was furnished by the city construction authority.

Position	Hourly Rate	Daily Payment (LS)
Unskilled Labour	0.12	0.96
Skilled Labour	0.20	1.60
Driver	0.25	2.00
Carpenter	0.25	2.00
Mason	0.25	2.00
Mechanic	0.25	2.00
Foreman	0.30	2.40

13.3 Miscellaneous Materials

i. Fuel and Oil

Cost of fuel and oil are shown in Table 7-7 below.

TABLE 7-7 BREAKDOWN OF FUEL AND OIL PRICES
(in El Obeid)

(LS/gal)

	Total	Tax	FC[1)]	LC
Fuel				
Benzine (Gasoline)	0.460	0.220	0.10	0.140
Gasoline (Diesel)	0.368	0.056	0.10	0.212
Oil				
Super	2.370	0.311	1.553	0.506
Diesel	1.900	0.293	1.209	0.398

Source: Shell Oil Company, Khartoum

Note: 1) Barrel of crude oil : $10.75
7.37 Barrel = 1 ton of crude oil

ii. Cement

There are two cement plants in the Sudan, one at Atbara and one at Kosti, which have a maximum daily production of 750 tons and 400 tons, respectively.

Ex works price is LS 25 per ton. For all cement to be used in this project, the unit price of Sudan product cement is adopted since the Kosti Plant is expected to increase production in the near future.

iii. Other Materials

TABLE 7-8 THE COST OF OTHER MATERIALS

(LS)

Item	Unit	CIF Price Port Sudan	Transport Local Cost	Taxes	Total
Bitumen	T	72.22	11.70	33.58	117.50
Cement	T		40.10	1.65	41.75
Reinforcing Bar	T		243.0	61.0	304.0
Structural Steel	T	156.0	105.0	94.0	355.0
Explosives	kg	0.98	0.15	0.39	1.52
Timber	m^3		150.0	10.0	160.0
Filler	T		18.10	0.55	18.65

NEX VII-14 COST

.1 Unit Cost per Work Item

Unit cost per work item is estimated in compliance with Peurifoy R.L. "Construction Planning, Equipment and Methods" 1970 and data obtained at the construction sites of El Ain dam and El Obeid Airport.

.2 Income Tax

The income tax component of the Sudan is determined by Table 6-20-10 in Annex VI.

.3 Cost for Equipment

The acquisition cost of equipment is based on the CIF price at Port Sudan, as shown in Annex VIII-12. The unit cost per work item is calculated by dividing into two categories - (a) equipment ownership cost and (b) equipment operating cost. The service years of equipment and the repair coefficient are shown in following Table 7-9, where the repair coefficient is the maximum percentage figures of all repair costs to the initial acquisition cost, and the required quantity of principal items of mechanical equipment are shown in Annex VIII-11.

.4 Overhead and Profit

In estimating the unit rate as shown in Tables 7-10-1～-7 of Annex VII-15, about 40% of the cost is added to cover the overhead and profit of contractors. (The percentage is revised in Chapter VIII.)

TABLE 7-9 DURABILITY AND REPAIR COEFFICIENT OF MECHANICAL EQUIPMENT

Mechanical Equipment	Economic Year	Durability Hours	Repair Coefficient
Air Compressor	7	6,000	0.75
Asphalt Distributor	8	10,000	0.75
Bull-dozer	8	10,000	0.75
Concrete Mixer	8	8,000	0.75
Concrete Vibrator	4	4,000	0.8
Crawler Drill	5	6,000	0.75
Crushing Plant	12	18,000	0.75
Excavator	8	8,000	0.75
Generator	8	8,000	0.75
Line Painting Unit	4	4,000	0.8
Motor Grader	8	10,000	0.75
Motor Scraper	8	10,000	0.75
Macadam Roller	10	10,000	0.75
Tired Roller	6	8,000	0.75
Soil Compacter	10	10,000	0.6
Tractor Shovel	8	10,000	0.75
Dump Truck	5	10,000	0.75
Flat Body Truck	7	4,000	0.3
Water Tanker	8	10,000	0.75
Fuel Car	8	10,000	0.75
Vibration Roller	5	8,000	0.8
Wheel Loader	8	10,000	0.75
Pump	6	6,000	1.0
Asphalt Plant	10	12,000	0.72
Asphalt Finisher	8	10,000	0.75

TABLE 7-10-1 PRICED BILL OF QUANTITY: ROUTE A

Item			Construction Section				Total
			1	2	3	4	
Earth Work	Clearing	Quantity (M^2)	1,020,370	1,013,790	905,940		2,952,100
		Rate	0.040	0.040	0.040		0.040
		Summation	41,300	41,000	36,700		119,000
	Filling	Quantity (M^3)	140,836	93,840	70,763		305,439
		Rate	0.637	0.637	0.637		0.637
		Summation	89,900	59,800	45,000		194,700
	Cutting (I)	Quantity (M^3)	336,668	351,630	314,223		1,002,521
		Rate	0.110	0.110	0.110		0.108
		Summation	37,100	38,800	34,700		110,600
	Cutting (II)	Quantity (M^3)	49,546	-	-		49,546
		Rate	0.715	-	-		0.715
		Summation	35,200	-	-		35,200
	Slope Protection	Quantity (M^2)	115,252	95,128	85,007		295,387
		Rate	0.360	0.360	0.360		0.360
		Summation	41,600	34,300	30,600		106,500
	Sub Total		245,100	173,900	147,000		566,000
Pavement Work	Surface	Quantity (M^2)	164,533	164,533	147,000		476,066
		Rate	0.796	0.796	0.829		
		Summation	131,000	131,000	122,000		384,000
	Base	Quantity (M^3)	28,200	28,200	25,200		81,600
		Rate	2.765	2.765	3.496		
		Summation	78,000	78,000	88,100		244,100
	Subbase	Quantity (M^3)	58,703	58,703	52,457		169,863
		Rate	2.623	2.623	3.353		
		Summation	154,000	154,000	175,900		483,900
	Shoulder	Quantity (M^3)	12,361	12,361	11,046		35,768
		Rate	1.905	1.905	1.905		1.905
		Summation	23,600	23,600	21,100		68,300
	Subgrade	Quantity (M^3)	37,673	41,664	44,330		123,667
		Rate	1.278	1.278	1.278		1.278
		Summation	48,200	53,200	56,600		158,000
	Sub Total		434,800	439,800	463,700		1,338,300
Bridge Work	L = 7.0M (1 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	L = 9.0M (1 span)	Quantity (P)	3	2	-		5
		Rate	10,433	10,400	-		
		Summation	31,300	20,800	-		52,100
	L = 7.0M x 2 (2 span)	Quantity (P)	-	1	1		2
		Rate	-	14,800	14,800		14,800
		Summation	-	14,800	14,800		29,600
	L = 9.0M x 2 (2 span)	Quantity (P)	-	-	1		1
		Rate	-	-	18,200		18,200
		Summation	-	-	18,200		18,200
	L = 9.0M x 3 (3 span)	Quantity (P)	2	-	-		2
		Rate	26,350	-	-		26,350
		Summation	52,700	-	-		52,700
	Sub Total		84,000	35,600	33,000		152,600

TABLE 7-10-1 PRICED BILL OF QUANTITY: ROUTE A

Item			Construction Section				Total
			1	2	3	4	
Box Culvert	2.0 x 1.5 (1 Cell)	Quantity (P)	-	-	1.0		1.0
		Rate	-	-	2,900		2,900
		Summation	-	-	2,900		2,900
	2.0 x 1.5 (2 Cells)	Quantity (P)	4.0	2.0	1.0		7.0
		Rate	4,725	4,725	4,600		
		Summation	18,900	9,300	4,600		32,800
	2.0 x 1.5 (3 Cells)	Quantity (P)	-	2.0	-		2.0
		Rate	-	6,200	-		6,200
		Summation	-	12,400	-		12,400
	Sub Total		18,900	21,700	7,500		48,100
Drainage	Pipe Culvert (ø1,000 x 1)	Quantity (P)	2	2	2		6
		Rate	1,100	1,100	1,100		1,100
		Summation	2,200	2,200	2,200		6,600
	Pipe Culvert (ø1,000 x 2)	Quantity (P)	1	-	-		1
		Rate	1,900	-	-		1,900
		Summation	1,900	-	-		1,900
	Pipe Calvert (ø1,000 x 3)	Quantity (P)	-	2	2		4
		Rate	-	2,700	2,700		2,700
		Summation	-	5,400	5,400		10,800
	Side Ditch	Quantity (M^3)	400	-	-		400
		Rate	22.25	-	-		22.25
		Summation	8,900	-	-		8,900
	Side Pipe Culvert	Quantity (M)	117	118	105		340
		Rate	22.94	22.94	22.94		22.94
		Summation	2,700	2,700	2,400		7,800
	Sub Total		15,700	10,300	10,000		36,000
Masonry Work	Stone Masonry	Quantity (M3)	561	-	-		561
		Rate	22.28	-	-		22.28
		Summation	12,500	-	-		12,500
	Sub Total		12,500	-	-		12,500
Total			811,000	681,300	661,200		2,153,500
Overhead and Profit							1,089,500
Economic Cost							3,243,000

Notes: 1) (P) ..... Places

2) Cutting (I) is excavation of earth side ditch.

3) Cutting (II) is road excavation.

TABLE 7-10-2 PRICED BILL OF QUANTITY: ROUTE B

Item			Construction Section 1	2	3	4	Total
Earth Work	Clearing	Quantity (M^2)	1,121,640	905,940	1,058,640		3,086,220
		Rate	0.040	0.040	0.040		
		Summation	45,300	36,700	42,800		124,800
	Filling	Quantity (M^3)	104,008	76,759	120,383		301,150
		Rate	0.637	0.637	0.637		
		Summation	66,400	48,900	76,700		192,000
	Cutting (I)	Quantity (M^3)	389,038	314,223	389,038		1,092,299
		Rate	0.110	0.110	0.110		
		Summation	42,900	34,700	42,900		120,500
	Cutting (II)	Quantity (M^3)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	Slope Protection	Quantity (M^2)	105,248	85,008	38,720		228,975
		Rate	0.360	0.360	0.360		
		Summation	38,000	30,600	13,900		82,500
	Sub Total		192,600	150,900	176,300		519,800
Pavement Work	Surface	Quantity (M^2)	182,000	147,000	182,000		511,000
		Rate	0.795	0.795	0.856		
		Summation	144,700	117,000	151,000		412,700
	Base	Quantity (M^3)	31,200	25,000	31,200		87,400
		Rate	2.772	2.772	3.500		
		Summation	86,500	69,200	109,200		204,900
	Subbase	Quantity (M^3)	64,948	52,458	64,948		182,354
		Rate	2.623	2.623	3.553		
		Summation	170,600	137,600	217,900		526,100
	Shoulder	Quantity (M^3)	13,676	11,046	13,676		38,398
		Rate	1.905	1.905	1.905		
		Summation	26,300	21,100	26,300		73,700
	Subgrade	Quantity (M^3)	45,913	44,331	36,192		126,436
		Rate	1.278	1.278	1.278		
		Summation	58,700	56,600	46,200		161,500
	Sub Total		486,800	401,500	550,600		1,438,900
Bridge Work	L = 7.0M (1 span)	Quantity (P)	2	1	1		4
		Rate	8,800	8,800	8,800		8,800
		Summation	17,600	8,800	8,800		35,200
	L = 9.0M (1 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	L = 7.0M x 2 (2 span)	Quantity (P)	-	3	-		3
		Rate	-	15,000	-		15,000
		Summation	-	45,000	-		45,000
	L = 9.0M x 2 (2 span)	Quantity (P)	-	1	1		2
		Rate	-	18,200	18,200		
		Summation	-	18,200	18,200		36,400
	L = 9.0M x 3 (3 span)	Quantity (P)	2	1	-		3
		Rate	26,350	26,600	-		
		Summation	52,700	26,600	-		79,300
	Sub Total		70,300	98,600	27,000		195,900

TABLE 7-10-2 PRICED BILL OF QUANTITY: ROUTE B

Item			Construction Section 1	2	3	4	Total
Box Culvert	2.0 x 1.5 (1 Cell)	Quantity (P)	1	-	1		2
		Rate	2,900	-	2,900		2,900
		Summation	2,900	-	2,900		5,800
	2.0 x 1.5 (2 Cells)	Quantity (P)	5	4	1		10
		Rate	4,725	4,725	4,600		6,633
		Summation	23,700	18,900	4,600		47,200
	2.0 x 1.5 (3 Cells)	Quantity (P)	3	-	1		4
		Rate	4,740	-	4,740		4,740
		Summation	18,600	-	4,740		23,540
	Sub Total		45,400	18,900	12,240		76,540
Drainage	Pipe Culvert (ø1,000 x 1)	Quantity (P)	2	2	4		8
		Rate	1,100	1,100	1,100		1,100
		Summation	2,200	2,200	4,400		8,800
	Pipe Culvert (ø1,000 x 2)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	Pipe Calvert (ø1,000 x 3)	Quantity (P)	-	-	2		2
		Rate	-	-	2,700		2,700
		Summation	-	-	5,400		5,400
	Side Ditch	Quantity (M^3)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	Side Pipe Culvert	Quantity (M)	130	105	130		365
		Rate	22.30	22.30	22.30		22.30
		Summation	2,900	2,400	2,900		8,200
	Sub Total		5,100	4,600	12,700		22,400
Masonry Work	Stone Masonry	Quantity (M3)	1,148	-	-		1,148
		Rate	22.28	-	-		22.28
		Summation	25,700	-	-		25,700
	Sub Total		25,700	-	-		25,700
Total			825,900	674,500	778,840		2,279,240
Overhead and Profit							1,154,300
Economic Cost							3,433,540

Notes: 1) (P) ..... Places

2) Cutting (I) is excavation of earth side ditch.

3) Cutting (II) is road excavation.

TABLE 7-10-3 PRICED BILL OF QUANTITY: ROUTE C

Item			Construction Section 1	2	3	4	Total
Earth Work	Clearing	Quantity (M^2)	1,025,931	1,198,259	983,592		3,207,782
		Rate	0.040	0.040	0.040		0.040
		Summation	41,500	48,300	39,800		129,600
	Filling	Quantity (M^3)	254,570	256,966	24,456		535,992
		Rate	0.637	0.637	0.637		
		Summation	162,700	164,100	15,400		342,200
	Cutting (I)	Quantity (M^3)	314,972	389,038	341,156		945,166
		Rate	0.110	0.110	0.110		
		Summation	34,700	42,900	37,700		115,300
	Cutting (II)	Quantity (M^3)	70,200	-	-		70,200
		Rate	0.710	-	-		0.710
		Summation	50,100	-	-		50,100
	Slope Protection	Quantity (M^2)	228,459	186,005	92,295		506,759
		Rate	0.362	0.451	0.451		
		Summation	82,700	84,000	41,600		208,300
	Sub Total		371,700	339,300	134,500		845,500
Pavement Work	Surface	Quantity (M^2)	161,000	182,000	159,633		502,633
		Rate	0.831	0.898	0.898		
		Summation	133,800	163,500	143,400		440,700
	Base	Quantity (M^3)	27,600	31,200	27,360		86,160
		Rate	3.496	4,387	4.959		
		Summation	96,500	136,900	135,700		369,100
	Subbase	Quantity (M^3)	57,454	64,948	56,954		179,356
		Rate	3.353	4.261	4.814		
		Summation	192,800	276,800	274,200		743,800
	Shoulder	Quantity (M^3)	12,098	13,676	11,993		37,767
		Rate	1.905	2.339	2.643		
		Summation	23,300	32,000	31,700		87,000
	Subgrade	Quantity (M^3)	80,566	94,627	107,013		282,206
		Rate	1.278	1.278	1.278		
		Summation	103,200	103,200	137,300		343,700
	Sub Total		549,600	712,400	722,300		1,984,300
Bridge Work	$L = 7.0^M$ (1 span)	Quantity (P)	2	-	-		3
		Rate	8,800	-	-		8,800
		Summation	26,400	-	-		26,400
	$L = 9.0^M$ (1 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	$L = 7.0^M \times 2$ (2 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	$L = 9.0^M \times 2$ (2 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	$L = 9.0^M \times 3$ (3 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	Sub Total		26,400	-	-		26,400

TABLE 7-10-3 PRICED BILL OF QUANTITY: ROUTE C

Item			Construction Section				Total
			1	2	3	4	
Box Culvert	2.0 x 1.5 (1 Cell)	Quantity (P)	2	4	4		10
		Rate	2,900	2,975	2,225		
		Summation	5,800	11,900	8,900		26,600
	2.0 x 1.5 (2 Cells)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	2.0 x 1.5 (3 Cells)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	Sub Total		5,800	11,900	8,900		26,600
Drainage	Pipe Culvert (ø1,000 x 1)	Quantity (P)	6	6	6		18
		Rate	1,133	1,133	1,133		1,133
		Summation	6,800	6,800	6,800		20,400
	Pipe Culvert (ø1,000 x 2)	Quantity (P)	6	13	5		24
		Rate	2,000	2,000	2,000		2,000
		Summation	12,000	26,300	10,000		48,300
	Pipe Calvert (ø1,000 x 3)	Quantity (P)	4	-	5		9
		Rate	2,775	-	2,775		4,240
		Summation	11,100	-	13,900		25,000
	Side Ditch	Quantity (M^3)	780	-	-		780
		Rate	22.25	-	-		22.25
		Summation	17,400	-	-		17,400
	Side Pipe Culvert	Quantity (M)	115	130	114		359
		Rate	22.94	22.30	22.94		
		Summation	2,500	2,900	2,500		7,900
	Sub Total		49,800	360,00	33,200		119,000
Masonry Work	Stone Masonry	Quantity (M3)	1,972	2,337	-		4,303
		Rate	22.28	22.28	-		58.75
		Summation	44,200	52,500	-		96,700
	Sub Total		44,200	52,500	-		96,700
Total			1,047,500	1,152,100	898,900		3,098,500
Overhead and Profit							1,570,100
Economic Cost							4,668,600

Notes: 1) (P) ..... Places

2) Cutting (I) is excavation of earth side ditch.

3) Cutting (II) is road excavation.

TABLE 7-10-4 PRICED BILL OF QUANTITY: ROUTE D

Item			Construction Section				Total
			1	2	3	4	
Earth Work	Clearing	Quantity (M^2)	836,828	1,023,804	919,285		2,779,911
		Rate	0.040	0.040	0.040		
		Summation	33,800	41,400	37,100		112,300
	Filling	Quantity (M^3)	104,841	85,827	78,299		268,967
		Rate	0.637	0.637	0.637		
		Summation	66,900	54,700	49,800		171,400
	Cutting (I)	Quantity (M^3)	237,913	296,567	305,096		839,576
		Rate	0.110	0.110	0.110		
		Summation	26,200	32,600	33,700		92,500
	Cutting (II)	Quantity (M^3)	286,464	301,004	71,466		658,934
		Rate	0.715	0.715	0.715		
		Summation	204,800	215,300	50,900		471,000
	Slope Protection	Quantity (M^2)	99,625	107,167	88,830		295,627
		Rate	0.362	0.451	0.451		
		Summation	36,000	48,300	40,200		124,500
	Sub Total		367,700	392,300	211,700		971,700
Pavement Work	Surface	Quantity (M^2)	140,033	17,500	15,200		466,233
		Rate	0.831	0.898	0.898		
		Summation	115,900	157,300	135,900		409,100
	Base	Quantity (M^3)	24,000	30,038	25,920		79,958
		Rate	3.491	4.957	4.957		
		Summation	83,800	148,900	128,500		361,200
	Subbase	Quantity (M^3)	49,959	62,451	53,956		166,366
		Rate	3.352	4.816	4.816		
		Summation	167,500	300,800	259,800		728,100
	Shoulder	Quantity (M^3)	10,519	13,150	11,361		35,030
		Rate	1.929	2.643	2.643		
		Summation	20,300	34,800	30,000		85,100
	Subgrade	Quantity (M^3)	27,840	36,366	40,958		105,164
		Rate	1.278	1.278	1.278		
		Summation	35,500	46,400	52,300		134,200
	Sub Total		423,000	688,200	606,500		1,717,700
Bridge Work	$L = 7.0^M$ (1 span)	Quantity (P)	3	-	-		3
		Rate	8,800	-	-		
		Summation	26,400	-	-		26,400
	$L = 9.0^M$ (1 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	$L = 7.0^M \times 2$ (2 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	$L = 9.0^M \times 2$ (2 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	$L = 9.0^M \times 3$ (3 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	Sub Total		26,400	-	-		26,400

TABLE 7-10-4 PRICED BILL OF QUANTITY: ROUTE D

Item			Construction Section				Total
			1	2	3	4	
Box Culvert	2.0 x 1.5 (1 Cell)	Quantity (P)	-	8	2		10
		Rate	-	3,000	2,900		
		Summation	-	24,000	5,800		29,800
	2.0 x 1.5 (2 Cells)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	2.0 x 1.5 (3 Cells)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	Sub Total		-	24,000	5,800		29,800
Drainage	Pipe Culvert (ø1,000 x 1)	Quantity (P)	4	4	9		17
		Rate	1,100	1,100	1,100		
		Summation	4,400	4,400	10,100		18,900
	Pipe Culvert (ø1,000 x 2)	Quantity (P)	3	3	-		6
		Rate	1,966	1,966	-		3,033
		Summation	5,900	5,900	-		11,800
	Pipe Culvert (ø1,000 x 3)	Quantity (P)	1	2	-		3
		Rate	2,600	2,700	-		
		Summation	2,600	5,400	-		8,000
	Side Ditch	Quantity (M^3)	1,640	2,072	484		4,196
		Rate	22.25	22.25	22.25		
		Summation	36,800	46,500	10,800		94,100
	Side Pipe Culvert	Quantity (M)	100	125	108		333
		Rate	22.94	22.30	22.30		35.90
		Summation	2,300	2,800	2,400		7,500
	Sub Total		52,000	65,000	23,300		140,300
Masonry Work	Stone Masonry	Quantity (M3)	146	-	-		146
		Rate	21.91	-	-		22.28
		Summation	3,200	-	-		3,200
	Sub Total		3,200	-	-		3,200
Total			872,300	1,169,500	847,300		2,889,100
Overhead and Profit							1,463,200
Economic Cost							4,352,300

Notes: 1) (P) ..... Places

2) Cutting (I) is excavation of earth side ditch.

3) Cutting (II)is road excavation.

TABLE 7-10-5 PRICED BILL OF QUANTITY: ROUTE E

Item			Construction Section 1	2	3	4	Total
Earth Work	Clearing	Quantity (M^2)	1,283,320	589,454	892,108		2,443,844
		Rate	0.040	0.040	0.040		
		Summation	52,000	23,700	36,000		111,700
	Filling	Quantity (M^3)	81,225	31,986	68,237		181,448
		Rate	0.637	0.637	0.637		
		Summation	51,700	20,200	43,500		115,400
	Cutting (I)	Quantity (M^3)	343,173	145,142	233,423		721,665
		Rate	0.110	0.110	0.110		
		Summation	37,900	15,800	25,700		79,400
	Cutting (II)	Quantity (M^3)	773,130	553,091	395,778		1,722,179
		Rate	0.751	0.715	0.715		
		Summation	553,500	395,900	283,200		1,232,600
	Slope Protection	Quantity (M^2)	134,784	61,625	97,989		322,907
		Rate	0.362	0.362	0.362		
		Summation	48,700	27,700	44,300		120,700
	Sub Total		743,800	483,300	432,700		1,659,800
Pavement Work	Surface	Quantity (M^2)	217,033	98,033	156,133		471,199
		Rate	0.838	0.895	0.895		
		Summation	180,300	87,800	140,200		408,300
	Base	Quantity (M^3)	37,200	16,800	26,760		80,760
		Rate	3.500	4.952	4.952		
		Summation	130,200	83,200	132,700		346,100
	Subbase	Quantity (M^3)	77,676	34,972	55,706		168,354
		Rate	3.354	4.816	4.816		
		Summation	260,600	168,400	268,300		697,300
	Shoulder	Quantity (M^3)	16,307	7,364	11,730		35,401
		Rate	1,920	2,643	2,643		
		Summation	31,300	19,500	31,000		81,800
	Subgrade	Quantity (M^3)	65,057	29,934	31,042		126,033
		Rate	1.278	1.278	1.278		
		Summation	83,300	38,100	39,600		161,000
	Sub Total		685,700	397,000	611,800		1,694,500
Bridge Work	L = 7.0M (1 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	L = 9.0M (1 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	L = 7.0M x 2 (2 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	L = 9.0M x 2 (2 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	L = 9.0M x 3 (3 span)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	Sub Total		-	-	-		-

TABLE 7-10-5 PRICED BILL OF QUANTITY: ROUTE E

Item			Construction Section				Total
			1	2	3	4	
Box Culvert	2.0 x 1.5 (1 Cell)	Quantity (P)	8	1	2		11
		Rate	3,000	2,900	2,900		
		Summation	24,000	2,900	5,800		32,700
	2.0 x 1.5 (2 Cells)	Quantity (P)	3	4	1		8
		Rate	4,733	4,725	4,600		
		Summation	14,200	18,900	4,600		37,700
	2.0 x 1.5 (3 Cells)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	Sub Total		38,200	21,800	10,400		70,400
Drainage	Pipe Culvert (ø1,000 x 1)	Quantity (P)	4	1	6		11
		Rate	1,100	1,100	1,132		
		Summation	4,400	1,100	6,800		12,300
	Pipe Culvert (ø1,000 x 2)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	Pipe Calvert (ø1,000 x 3)	Quantity (P)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	Side Ditch	Quantity (M^3)	3,156	1,720	2,680		7,556
		Rate	22.50	22.50	22.50		
		Summation	70,900	38,500	60,200		169,600
	Side Pipe Culvert	Quantity (M)	155	70	111		336
		Rate	22.59	21.42	22.59		
		Summation	3,500	1,500	2,500		7,500
	Sub Total		78,800	41,100	69,500		189,400
Masonry Work	Stone Masonry	Quantity (M3)	-	-	-		-
		Rate	-	-	-		-
		Summation	-	-	-		-
	Sub Total		-	-	-		-
Total			1,546,500	943,200	1,124,400		3,614,100
Overhead and Profit							1,811,200
Economic Cost							5,425,300

Notes: 1) (P) ..... Places

2) Cutting (I) is excavation of earth side ditch.

3) Cutting (II) is road excavation.

TABLE 7-10-6 PRICED BILL OF QUANTITY: ROUTE F

Item			Construction Section				Total
			1	2	3	4	
Earth Work	Clearing	Quantity (M^2)	1,601,741	965,596	457,145	1,796,279	4,820,761
		Rate	0.040	0.040	0.040	0.040	
		Summation	64,900	38,900	18,400	72,700	194,900
	Filling	Quantity (M^3)	202,799	79,337	24,495	144,812	451,443
		Rate	0.637	0.637	0.637	0.637	0.637
		Summation	129,400	50,600	15,500	92,400	287,900
	Cutting (I)	Quantity (M^3)	493,030	219,957	93,793	450,088	1,246,867
		Rate	0.110	0.110	0.110	0.110	
		Summation	54,400	24,200	9,000	49,800	137,400
	Cutting (II)	Quantity (M^3)	213,961	648,808	607,832	1,282,760	2,753,361
		Rate	0.715	0.715	0.715	0.715	
		Summation	152,900	464,300	434,900	918,300	1,970,400
	Slope Protection	Quantity (M^2)	296,121	109,686	52,361	198,598	656,766
		Rate	0.362	0.362	0.451	0.451	
		Summation	107,400	39,600	23,500	89,800	260,300
	Sub Total		509,000	617,600	501,300	1,223,000	2,850,900
Pavement Work	Surface	Quantity (M^2)	239,066	170,500	79,200	305,200	793,966
		Rate	0.838	0.838	0.925	0.925	
		Summation	200,700	142,800	72,500	282,600	698,600
	Base	Quantity (M^3)	40,980	29,220	13,572	52,358	136,130
		Rate	4.963	4.963	6.882	6.882	
		Summation	203,400	145,000	93,400	360,700	802,500
	Subbase	Quantity (M^3)	85,307	60,828	28,252	10,888	330,764
		Rate	4.816	4.816	6.272	6.272	
		Summation	411,000	292,900	177,200	68,200	949,300
	Shoulder	Quantity (M^3)	17,963	12,809	5,950	22,927	59,649
		Rate	1.920	1.920	2.643	2.643	
		Summation	34,500	24,600	15,700	61,000	135,800
	Subgrade	Quantity (M^3)	67,238	39,844	15,743	65,025	187,851
		Rate	1.278	1.278	1.278	1.278	
		Summation	86,100	50,900	20,000	83,300	240,300
	Sub Total		935,700	656,200	378,800	855,800	2,826,500
Bridge Work	$L = 7.0^M$ (1 span)	Quantity (P)	-	-	-	-	-
		Rate	-	-	-	-	-
		Summation	-	-	-	-	-
	$L = 9.0^M$ (1 span)	Quantity (P)	-	-	-	-	-
		Rate	-	-	-	-	-
		Summation	-	-	-	-	-
	$L = 7.0^M \times 2$ (2 span)	Quantity (P)	3	-	-	-	3
		Rate	14,800	-	-	-	14,800
		Summation	44,400	-	-	-	44,400
	$L = 9.0^M \times 2$ (2 span)	Quantity (P)	-	-	-	-	-
		Rate	-	-	-	-	-
		Summation	-	-	-	-	-
	$L = 9.0^M \times 3$ (3 span)	Quantity (P)	-	-	-	-	-
		Rate	-	-	-	-	-
		Summation	-	-	-	-	-
	Sub Total		44,400	-	-	-	44,400

TABLE 7-10-6 PRICED BILL OF QUANTITY: ROUTE F

Item			Construction Section				Total
			1	2	3	4	
Box Culvert	2.0 x 1.5 (1 Cell)	Quantity (P)	15	7	4	12	38
		Rate	3,000	3,000	2,975	3,000	
		Summation	45,000	21,000	11,900	36,000	113,900
	2.0 x 1.5 (2 Cells)	Quantity (P)	-	1	-	1	2
		Rate	-	4,600	-	4,600	
		Summation	-	4,600	-	4,600	9,200
	2.0 x 1.5 (3 Cells)	Quantity (P)	-	-	-	-	-
		Rate	-	-	-	-	-
		Summation	-	-	-	-	-
	Sub Total		45,000	25,600	11,900	40,600	123,100
Drainage	Pipe Culvert (ø1,000 x 1)	Quantity (P)	-	3	1	6	10
		Rate	-	1,100	1,100	1,133	
		Summation	-	3,300	1,100	6,800	11,200
	Pipe Culvert (ø1,000 x 2)	Quantity (P)	-	-	-	1	1
		Rate	-	-	-	1,900	1,900
		Summation	-	-	-	1,900	1,900
	Pipe Culvert (ø1,000 x 3)	Quantity (P)	2	-	-	-	2
		Rate	2,700	-	-	-	2,700
		Summation	5,400	-	-	-	5,400
	Side Ditch	Quantity (M^3)	1,000	3,860	2,284	5,404	12,428
		Rate	22.50	22.50	22.50	22.50	
		Summation	22,500	86,600	51,300	121,500	281,900
	Side Pipe Culvert	Quantity (M)	177	122	56	218	573
		Rate	22.59	22.95	21.42	22.95	
		Summation	4,000	2,800	1,200	5,000	13,000
	Sub Total		31,900	92,700	53,600	135,200	313,400
Masonry Work	Stone Masonry	Quantity (M^3)	761	250	-	220	1,231
		Rate	22.59	22.00	-	22.00	
		Summation	17,000	5,500	-	4,800	27,300
	Sub Total		17,000	5,500	-	4,800	
Total			1,583,000	1,397,600	945,600	2,259,400	6,185,600
Overhead and Profit							3,058,000
Economic Cost							

Notes: 1) (P) ..... Places

2) Cutting (I) is excavation of earth side ditch.

3) Cutting (II) is road excavation.

TABLE 7-10-7 PRICED BILL OF QUANTITY: ROUTE ACCESS ROAD

Item			Construction Section				Total
			1	2	3	4	
Earth Work	Clearing	Quantity (M^2)	794,761	801,826			1,596,587
		Rate	0.040	0.040			0.040
		Summation	31,790	32,810			64,600
	Filling	Quantity (M^3)	188,817	166,092			354,909
		Rate	0.637	0.637			0.637
		Summation	120,276	106,624			226,900
	Cutting (I)	Quantity (M^3)	299,260	266,341			565,601
		Rate	0.110	0.110			0.110
		Summation	33,068	29,432			62,500
	Cutting (II)	Quantity (M^3)	-	217,989			217,989
		Rate	-	0.710			0.710
		Summation	-	155,800			155,800
	Slope Protection	Quantity (M^2)	48,000	87,360			135,360
		Rate	0.451	0.451			0.451
		Summation	21,666	39,434			61,100
	Sub Total		206,800	364,100			570,900
Pavement Work	Surface	Quantity (M^2)	73,000	64,970			137,970
		Rate	0.898	0.898			0.898
		Summation	65,344	58,156			123,500
	Base	Quantity (M^3)	12,080	12,563			24,643
		Rate	4.957	4.957			4.958
		Summation	59,902	62,298			122,200
	Subbase	Quantity (M^3)	18,201	18,928			37,129
		Rate	4.816	4.816			4.816
		Summation	89,649	91,151			178,800
	Shoulder	Quantity (M^3)	6,320	6,573			12,893
		Rate	2.652	2.652			2.652
		Summation	16,764	17,436			34,200
	Subgrade	Quantity (M^3)	11,403	10,400			21,803
		Rate	1.278	1.278			
		Summation	14,487	13,213			27,700
	Sub Total		244,146	242,254			486,400
Bridge Work	L = 7.0M (1 span)	Quantity (P)	-	-			-
		Rate	-	-			-
		Summation	-	-			-
	L = 9.0M (1 span)	Quantity (P)	-	-			-
		Rate	-	-			-
		Summation	-	-			-
	L = 7.0M x 2 (2 span)	Quantity (P)	-	-			-
		Rate	-	-			-
		Summation	-	-			-
	L = 9.0M x 2 (2 span)	Quantity (P)	-	-			-
		Rate	-	-			-
		Summation	-	-			-
	L = 9.0M x 3 (3 span)	Quantity (P)	-	-			-
		Rate	-	-			-
		Summation	-	-			-
	Sub Total		-	-			-

TABLE 7-10-7 PRICED BILL OF QUANTITY: ROUTE ACCESS ROAD

Item			Construction Section 1	2	3	4	Total
Box Culvert	2.0 x 1.5 (1 Cell)	Quantity (P)	2	3			5
		Rate	2,980	2,980			2,980
		Summation	5,960	8,940			14,900
	2.0 x 1.5 (2 Cells)	Quantity (P)	-	-			-
		Rate	-	-			-
		Summation	-	-			-
	2.0 x 1.5 (3 Cells)	Quantity (P)	-	-			-
		Rate	-	-			-
		Summation	-	-			-
	Sub Total		5,960	8,940			14,900
Drainage	Pipe Culvert (ø1,000 x 1)	Quantity (P)	6	5			11
		Rate	1,145	1,145			1,145
		Summation	6,872	5,728			12,600
	Pipe Culvert (ø1,000 x 2)	Quantity (P)	-	-			-
		Rate	-	-			-
		Summation	-	-			-
	Pipe Calvert (ø1,000 x 3)	Quantity (P)	-	-			-
		Rate	-	-			-
		Summation	-	-			-
	Side Ditch	Quantity (M^3)	-	1,128			1,128
		Rate	-	22.30			22.30
		Summation	-	25,200			25,200
	Side Pipe Culvert	Quantity (M)	100	104			204
		Rate	23.00	23.00			23.00
		Summation	2,300	2,400			4,700
	Sub Total		9,172	33,328			42,500
Masonry Work	Stone Masonry	Quantity (M^3)	-	-			-
		Rate	-	-			-
		Summation	-	-			-
	Sub Total		-	-			-
Total			466,078	648,632			1,114,700
Overhead and Profit							551,000
Economic Cost							1,665,700

Notes: 1) (P) ..... Places

2) Cutting (I) is excavation of earth side ditch.

3) Cutting (II) is road excavation.

ANNEX VII-16 MAINTENANCE AND REPAIR COST

Cost of maintenance and repair is usually calculated under two categories: one is daily maintenance and repair and the other is periodic repair.

16.1 Penetration Pavement

i. Daily Maintenance and Repair

Repair of penetration (DBST) pavement by patching,etc., must be done immediately after observation of defects to avoid enlargement of defects and serious damage. Accordingly, it is quite important to arrange for stand-by workers and equipment. The organization model repair team is shown in the following Table 7-11-1. Cost for annual maintenance is shown in Table 7-11-2.

ii. Miscellaneous Works

For clearing side ditches and culverts and other routine miscellaneous works, the following cost estimate is applied in the study. Assuming two-man work a day per week,

$$\frac{\text{2 Labourers}}{\text{7 days (One Week)}} \times 260 \text{ days} \times \text{LS } 0.96 = \text{LS } 71.3$$

Materials to be used: additional 25%

Economic Cost : 70%

$$71.3 \left(1 + 0.25 \times 0.70 \right) = \text{LS } 83.8$$

To the above total cost, 40% is added as an overhead charge.

TABLE 7-11-1 A ROAD REPAIR TEAM AND REQUIRED EQUIPMENT

Classification	Quantity	Remarks
Labour		
Foreman	1	General supervision, Technical instruction
Driver for worker transport	1	
Truck driver	1	Material transportation
Roller driver	1	
Bitumen and aggregate spray worker	3	
Rake man	1	Raking and finishing work
Scavenger	1	Cleaning, removal of surplus soils
Guard and traffic man	2	
Machinery		
Labour transport car	1	Transportation of labour and equipment
Truck	1	Transportation of aggregate, bitumen. 4-ton dump-car
Sprayer	1	For tack coat
Roller	1	
Vibroplate	1	
Equipment		
Picks, shovels	1 lot	
Materials		
Aggregate	2 - 3 M^3	
Bitumen	300 L	

TABLE 7-11-2 UNIT COST OF ROAD MAINTENANCE ON BITUMINOUS SURFACED ROAD

		LS/M^2	Economic cost
1.	Prime Coat (or Tack Coat) 1.5 Kg/M^2 MC 70 1.5 x 0.087 (87 LS/T)	0.131	
2.	Aggregate 0.02 x 1.0 x 1.0 x 3.876	0.078	
3.	Spreading and Compaction	0.030	
4.	Bitumen Spreading 1.3 Kg/M^2 MC 70 1.3 x 0.087	0.113	
5.	3/8" Aggregate 0.01 x 1.0 x 1.0 x 3.876	0.039	
6.	Spreading and Compaction	0.020	
7.	Bitumen Spray 1.0 x 0.087	0.087	
8.	Sand Spray 0.005 x 2.335	0.012	
9.	Sub Total	0.510 x 0.84 = 0.428	
10.	Mobilization Cost (5% of 9)	0.025 x 0.95 = 0.024	
11.	Supervising and Engineering (14% of 9)	0.070 x 0.91 = 0.064	
12.	Total		0.516

13. Cost per Kilometer for 7-meter width pavement
= 7.0 x 1,000 x 0.516 = 3,612 LS/KM

14. Assuming annual cost is 1% of the above working cost for roads with less than 500 average daily traffic (ADT)

Annual cost: 3,612 x 0.01 = 36 LS/KM

Accordingly, annual maintenance cost of penetration pavement for roads is as follows.

Patching Cost	Miscellaneous	Management	Total LS/km
36	83.8	47.9	168

iii. Periodic Repair

As previously mentioned, working cost for 7-metre width penetration pavement is 3,612 LS/km. If there is less than 500 ADT, it is determined that periodic resurfacing is to be carried out every seven to eight years.

16.2 Other Types of Pavement

Annual maintenance and repair costs for asphalt concrete surfaced roads are calculated in a similar way to penetration pavement roads. These costs are summarized in Table 7-11-3. The estimate of periodic resurfacing costs in terms of economic cost are also shown in the table.

ANNEX VII-16

TABLE 7-11-3 SUMMARY OF MAINTENANCE AND REPAIR COST

(LS/km)

ADT (Average Daily Traffic)	Annual Maintenance and Repair Costs	Periodic Resurfacing Costs
DBST W = 7.0 m		
< 500	168	3,612
ASPHALT CONCRETE W = 7.0 m		
>500	138	14,658

ANNEX VIII

TABLE 8-1 MINOR ALTERNATIVES

		Route						
		J. Kordofan Bypass		Rahad Bypass			Um Ruaba Bypass	
		Bypass A	Bypass B	Bypass C	Bypass D	Route E	Bypass F	Route G
Distance	Main (km)	14.2	14.8	13.7	14.2	16.3	6.85	6.56
	Access	-	-	2.66	1.53	-	1.04	-
Minimum Horizontal Alignment (m)		R=1,000	R=2,000	R=5,000	R=3,500	R=400	R=10,000	R=10,000
Maximum Gradient		i=2.60% L=1,350 m	i=0.85 L=2,800	i=2.466 L=650	i=2.76 L=450	i=2.76 L=450	i=0.59 L=800	i=0.975 L=400
Number of Structures	Bridges	2	3	-	-	-	-	-
	Boxes	2	4	-	-	-	-	-
	Pipes	6	4	9	8	8	3	3
Construction Cost (LS)								
Earthwork		367,000	312,000	278,000	293,000	296,000	102,000	71,000
Pavement		377,000	393,000	418,000	433,000	516,000	271,000	269,000
Structure		185,000	222,000	19,000	17,000	17,000	5,000	5,000
Access Road		-	-	135,000	62,000	-	53,000	-
Total in Economic Cost		929,000	927,000	850,000	805,000	829,000	431,000	345,000

TABLE 8-2 COST BY STAGED CONSTRUCTION PLAN

Rahad - Semeih
Distance 20.1 km

	Type A	Type B	Type C	Type D	Type E
1st (1981)					
Earthwork	658	655	647	611	658
Pavement	613	590	533	477	551
Structures	68	68	68	68	68
Sub Total	1,339	1,313	1,248	1,156	1,277
Add. Cost	374	367	348	323	357
Total	1,713	1,680	1,596	1,379	1,634
Cost/km	85.2	83.6	79.4	68.6	81.3
2nd (1996)					
Earthwork	-	-	-	75	-
Pavement	324	324	324	393	324
Sub Total	324	324	324	468	324
Add. Cost	90	90	90	131	90
Total	414	414	414	599	414
Cost/km	20.6	20.6	20.6	29.8	20.6
GRAND TOTAL:	2,127	2,094	2,010	1,978	2,048

ANNEX VIII-3 DESIGNS OF PAVEMENT STRUCTURE

3-1 Design Standards

These pavement structures are designed by applying three pavement standards.

a) US AASHTO, AASHTO Interim Guide for Design of Pavement Structure, 1972

b) UK Road Research Laboratory, Road Note 31: A Guide to the Structural Design of Bituminous-Surfaced Roads in Tropical and Subtropical Countries, and Road Note 29 : A Guide to the Structural Design of Pavements for New Roads.

c) UNESCO, Low Cost Roads, 1971

3-2 Pavement Structure

a) AASHTO

i) By applying Kentucky curve "A" to CBR value of 9%, the bearing capacity of the sub-grade soil "s" is identified as s=5.8 in FIG. 8-1-1. Assuming a regional coefficient of R=1.0, the thickness index of pavement structure SN is determined as SN=6.0 cm. Thickness for each layer is calculated by the following formula with the given layer coefficients of a1 to a3.

$SN = a_1D_1 + a_2D_2 + a_3D_3$

Where a_1 = Layer coefficient for surface course:
0.24 for DBST, 0.44 for A.C.

a_2 = Layer coefficient for base course : 0.11

a_3 = Layer coefficient for subbase course : 0.07

D_1, D_2 and D_3 denote actual thickness in cm of surface, base, and subbase course, respectively.

ii) It is determined that for AASHTO standards an over-laying of premix bituminous surface (asphalt concrete) in 5 cm thickness should be done when the accumulated equivalent standard axle load number reaches 0.70×10^6. It is forecasted the overlaying will be in 1996.

b) Road Note 29 and 31

The design standards apply the same equivalent axle loading index as AASHTO. For this road of initial construction with DBST surfacing, a chart in FIG. 8-1-2 of 150-1500 commercial vehicles per day in Road Note 31 and a chart in FIG.8-1-3 thickness of subbase in Road Note 29 are applied to determine the pavement thickness. An overlaying with premix bituminous-surface for 5 cm thickness is to be laid down when the accumulated axle loading number reaches 0.5×10^6. It will be reached in 11th year (1993) of the service of the road.

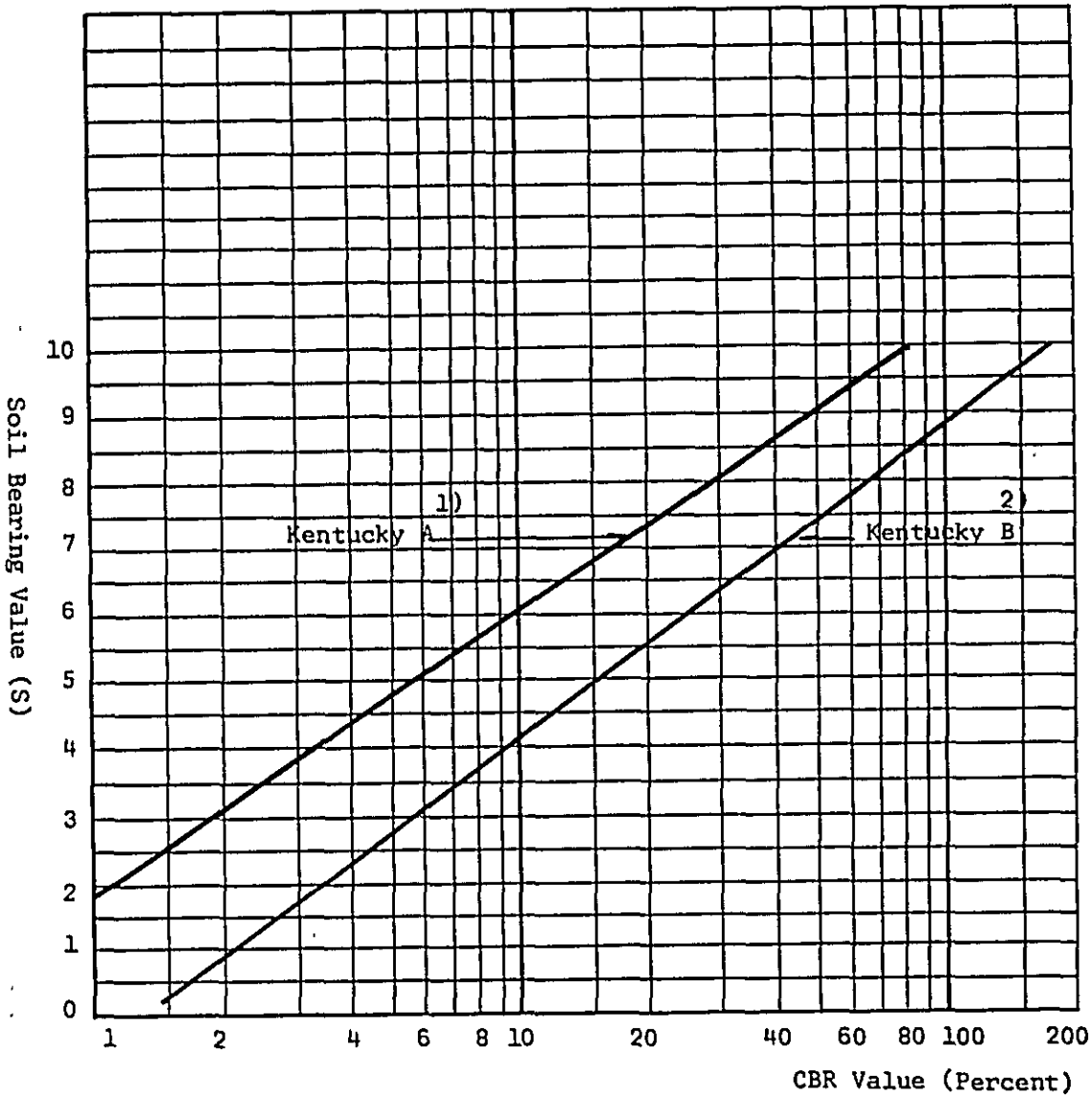
c) Low Cost Roads

The pavement design applied by the standards of Low Cost Roads shows the same result as in Road Note 31. FIG. 8-1-4 shows the pavement structure by Low Cost Roads.

3-3 Results

The thickness of pavement and the estimated construction cost determined by these design standards are shown in Table 8-3, Annex VIII-3. AASHTO will result in higher cost pavement work.

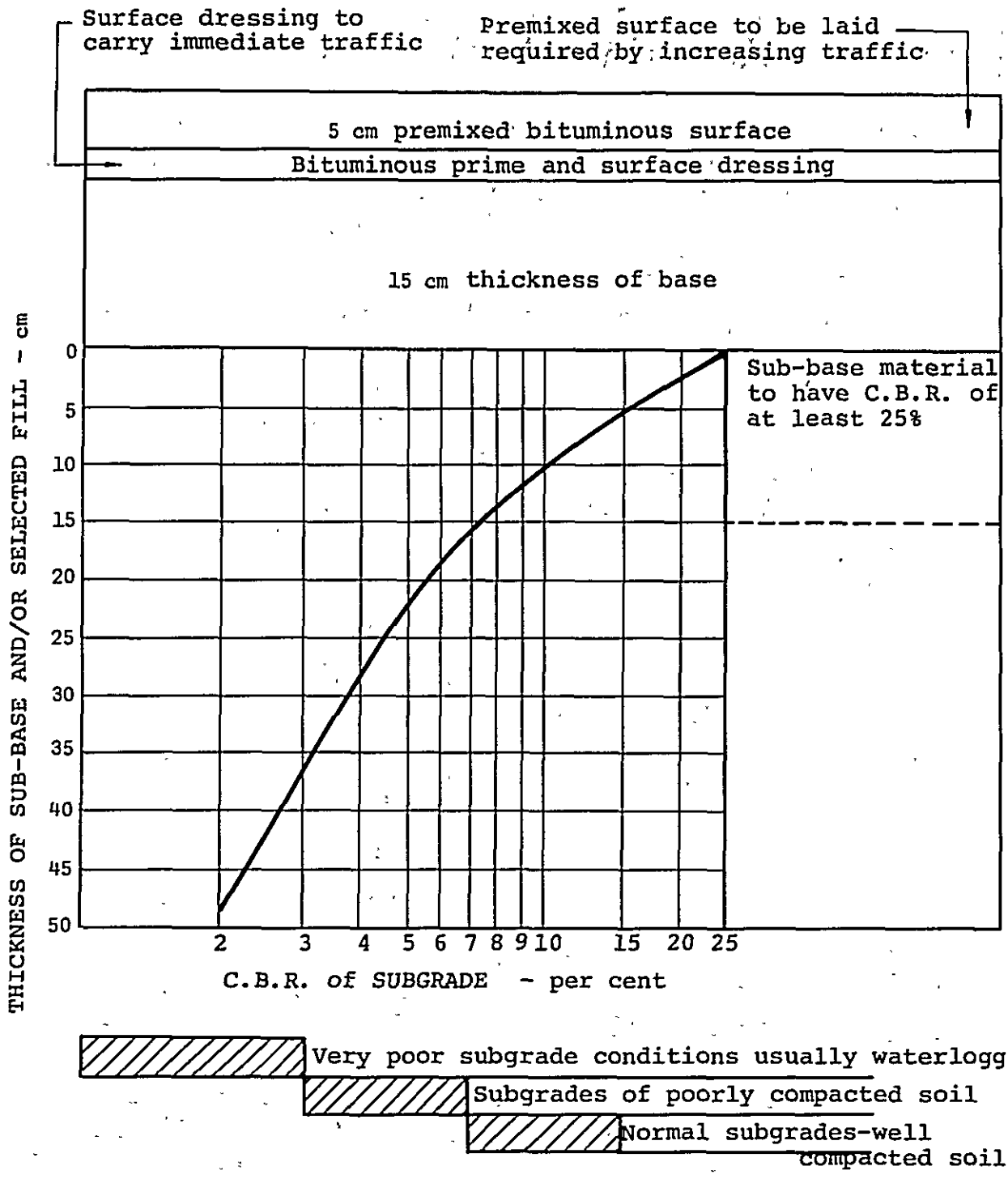
FIG. 8-1-1 AASHTO SOIL BEARING VALUE CHART



Notes: 1) Kentucky A curve uses for the crushed rock base courses.

2) Kentucky B curve uses for the bituminous, stabilized base courses.

Source: Hugh A. Wallace and J. Rogers Martin Asphalt Pavement Engineering (New York, Mc Graw Hill Book Co., 1967, p227, Fig. 10-31. Correlation chart for estimating soil-support values by AASHTO is transformed into this Chart.)



APPROXIMATE GUIDE TO SUBGRADE CONDITIONS

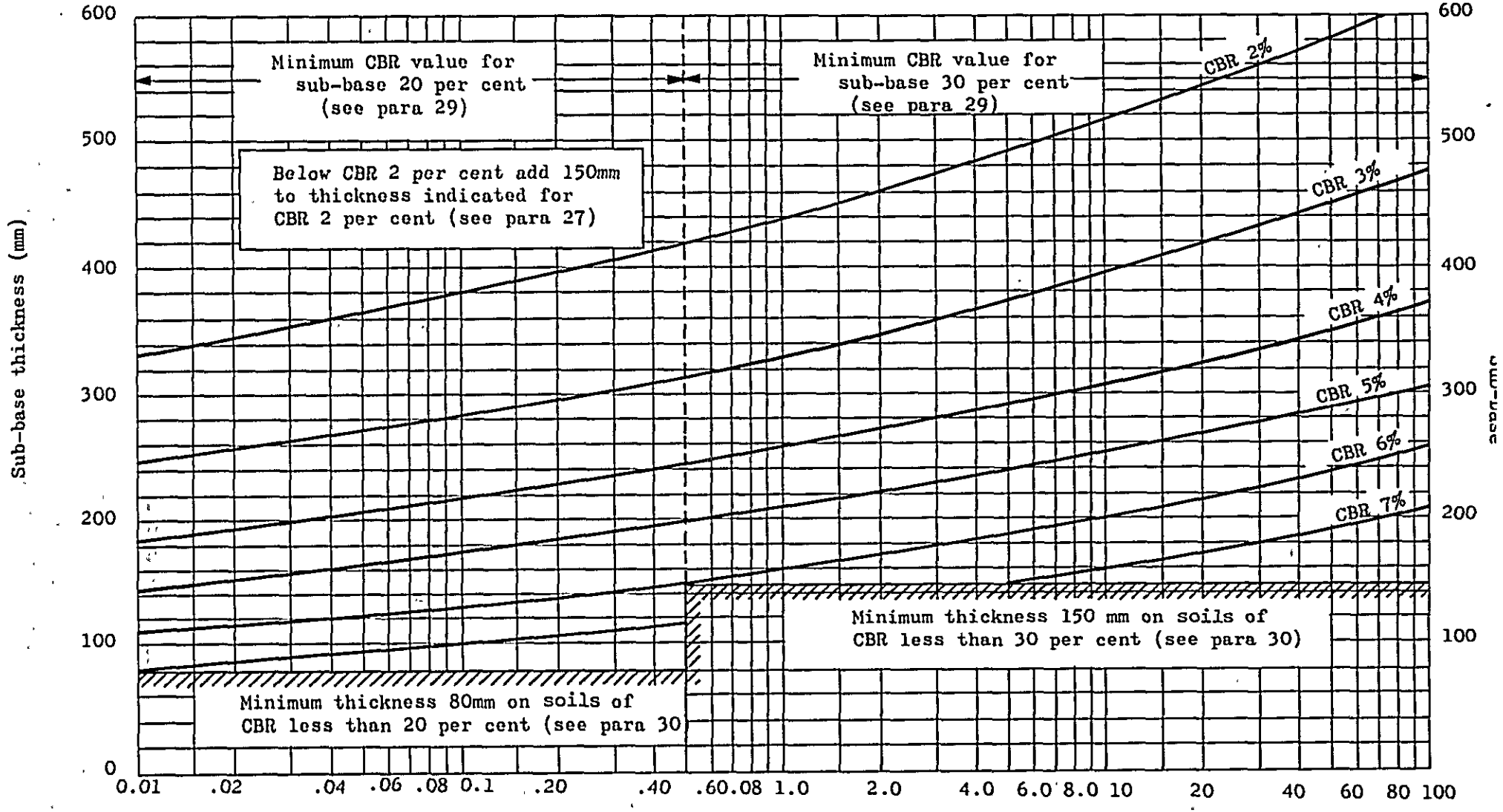
DESIGN CHART 2

(150-1500 commercial vehicles per day)

Source: U.K. RRL, Road Note 31, A Guide to the Structural Design of Bituminou surfaced Roads in Tropical and Sub-tropical Countries.

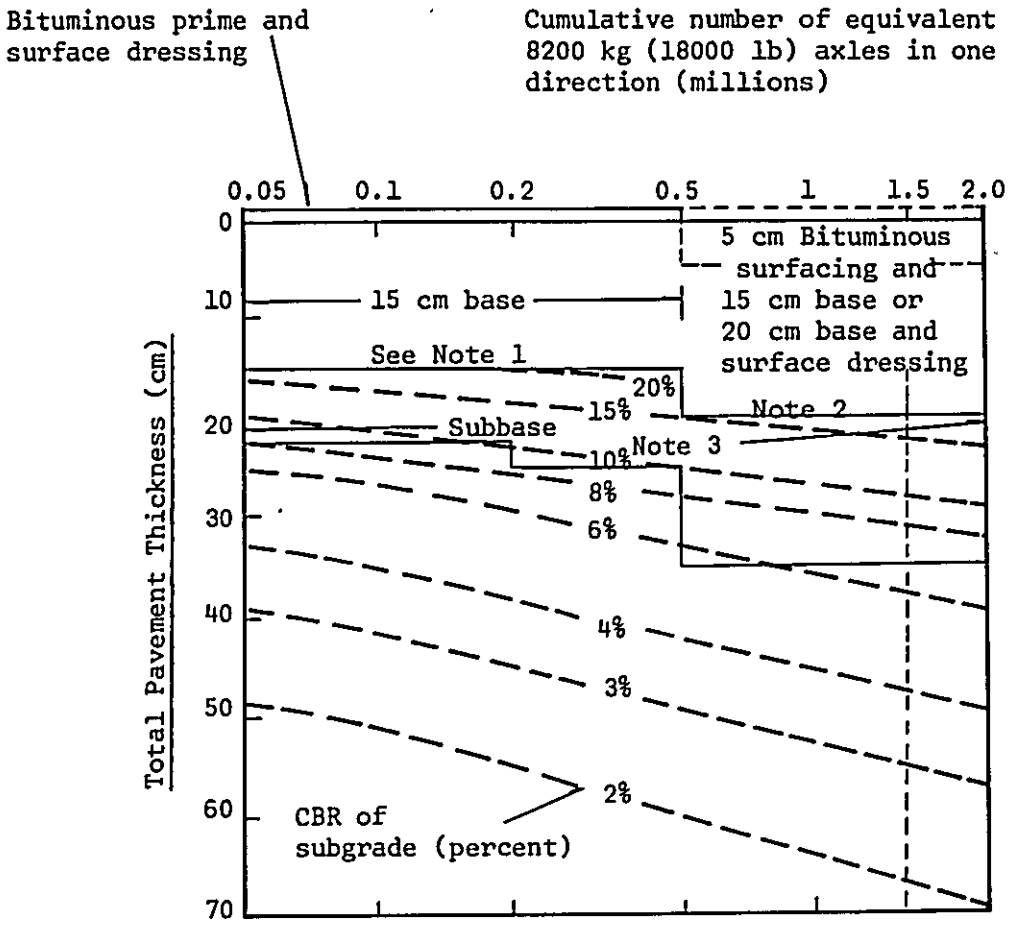
FIG. 8-1-3 THICKNESS OF SUBBASE

ANNEX VIII-3



Source: U.K. RRL, Road Note 29, A Guide to the Structual Design of Pavements for New Roads, 1970, p.25

FIG. 8-1-4 PAVEMENT DESIGN CHART FOR FLEXIBLE PAVEMENTS



Notes: 1) The thickness of thin bituminous surfacing less than 2 cm deep, such as multiple surface dressings, is neglected.

2) The additional thickness required on roads designed to carry more than 0.5 million equivalent 8200 kg axles can be provided at the time of construction by increasing the base thickness to 20 cm under a bituminous prime and surface dressing or by using a 15 cm base under a 5 cm premixed bituminous surfacing. Where an existing road is being strengthened, a 5 cm premixed bituminous surfacing is appropriate for flows up to 2.5 million equivalent 8200 kg axles.

3) Subbase materials are to have a minumum C.B.R. of 25% at the appropriate density and moisture conditions.

4) The pavement thickness shown are average thickness and are subject to normal working tolerances. Thus a nominal 15 cm base layer may occasionally have points with a minimum thickness of 11-12 cm but the average thickness would be expected to be in the range 14-16 cm.

Source: UNESCO Low Cost Roads
(London, Butterworths, 1971)

TABLE 8-3 PAVEMENT STRUCTURE AND COST

ANNEX VIII-3

	AASHTO (cm)	R.N. 31 Low Cost Roads (cm)	AASHTO (LS'000)	R.N. 31 Low Cost Roads (LS '000)
The first staged construction				
Double Bituminous Surface Treatment	3	3		
Crushed Rock and/or Gravel Base CBR≥80	15	15		
Gravel Subbase CBR≥25	30	15		
Total	48	33	590	480
Cost/km	-	-	29.3/km	23.9/km
The second staged construction				
Asphalt concrete surfacing	5	5	324	324
Crushed rock and/or gravel base CBR≥80	15	15		
Gravel subbase CBR≥25	30	15		
Total	50	35	324	324
Cost/km	-	-	16.1/km	16.1/km

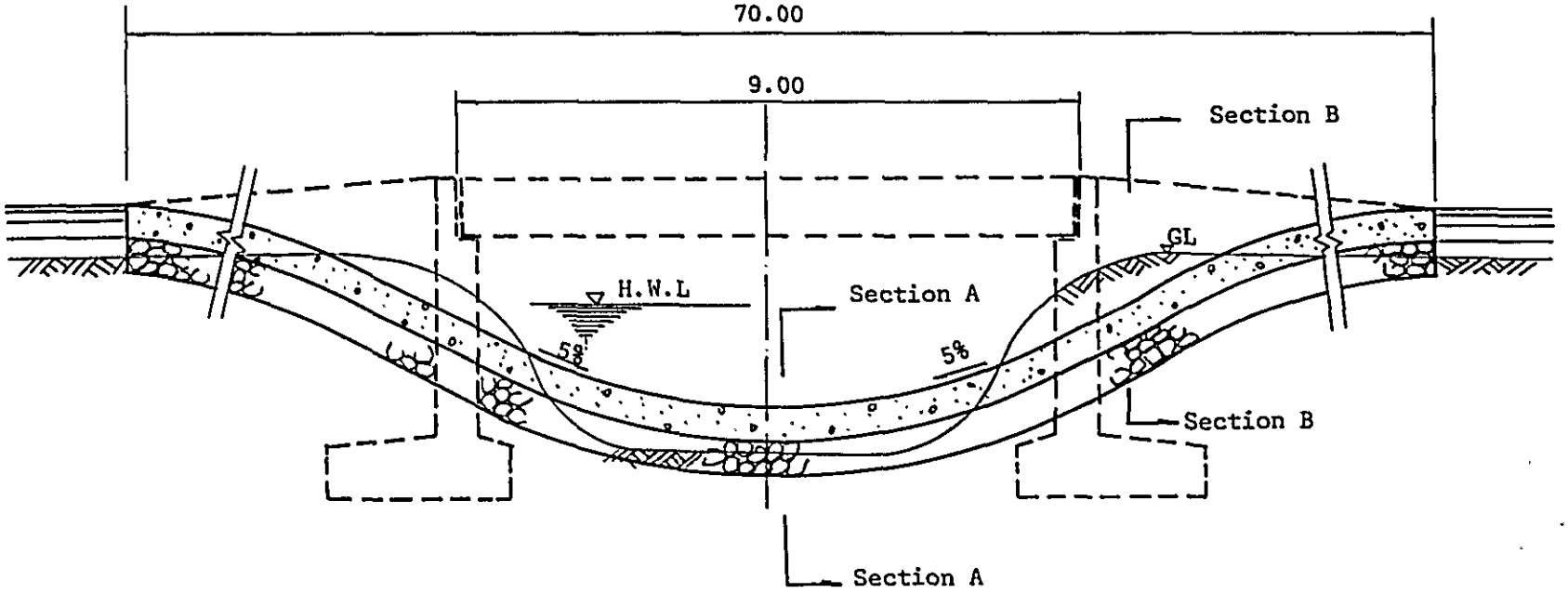
ANNEX VIII-4

TABLE 8-4 LIST OF BRIDGES

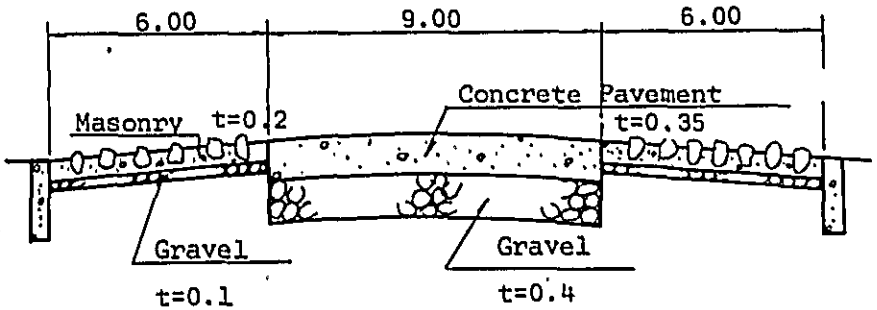
No.	Station	Bridge Length (m)	Name of Watercourse
1	5 + 250	9.0	
2	10 + 790	9.0	
3	11 + 090	9.0	K. El Banat
4	19 + 730	3 x 9.0 = 27.0	K. El Banat
5	21 + 290	3 x 9.0 = 27.0	K. El Baggara
6	25 + 830	9.0	
7	29 + 500	2 x 7.0 = 14.0	
8	43 + 850	9.0	K. Nawa
9	49 + 200	2 x 7.0 = 14.0	"
10	54 + 400	2 x 9.0 = 18.0	"
11	78 + 150	7.0	
12	81 + 050	7.0	
13	82 + 970	7.0	

PROFILE

FIG. 8 - 2 PROFILE OF BRIDGES



Section A-A



Section B-B

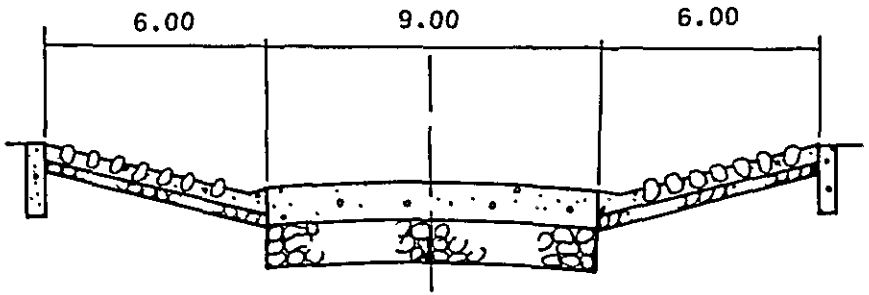


TABLE 8-5 ECONOMIC COST OF BRIDGES

(LS)

	Normal Bridge			Irish Bridge		
	No.	Unit Cost *	Total Cost	No.	Unit Cost *	Total Cost
7 m span	3	14,120	42,360	3	15,100	45,300
9 m span	5	18,760	93,800	5	15,100	75,500
7 m x 2 span	2	22,320	44,640	2	15,100	30,200
9 m x 2 span	1	27,852	27,852	1	22,120	22,120
9 m x 3 span	2	39,340	78,680	2	22,120	44,240
Total			287,332			217,360

Note: * = Unit cost includes all engineering works of approach sections.

TABLE 8-6 ECONOMIC COST OF RAILWAY CROSSING

(LS)

	Bridge	Approach	Crossing	Total
Over Crossing	26,059	107,942	-	134,001
Level Crossing	-	4,325	1,429	5,754

TABLE 8-7-1 CONSTRUCTION COST

Section Town
Distance 2.0 km

(LS in 1977 Price)

	Unit	Unit Price Economic	Unit Price Financial	Quantity	Economic Cost	Financial Cost
A. Earthwork and Pavement						
1. Clearing	m^2	0.040	0.043	68,308	2,700	2,900
2. Earthwork fill	m^3	0.635	0.768	17,987	11,400	13,800
3. Cutting	m^3	-	-	-	-	-
4. Ditch cutting	m^3	0.096	0.102	17,715	1,700	1,800
5. Preparation of formation	m^2	0.075	0.092	12,000	900	1,100
6. Slope protection	m^3	0.343	0.420	9,040	3,100	3,800
7. Subbase	m^3	2.585	3.400	3,560	9,200	12,100
8. Base	m^3	2.710	3.542	2,400	6,500	8,500
9. Prime coat	T	83.4	116.7	18	1,500	2,100
10. Surface (DBST)	m^2	0.542	0.725	12,000	6,500	8,700
11. Shoulder	m^3	1.836	2.416	1,035	1,900	2,500
Sub-Total					45,400	57,300
B. Structures	U					
12. Bridge		-	-	-	-	-
13. Box Culvert 2.0 x 1.5 2 cells	U	4,650	5,600	2	9,300	11,200
14. Pipe	U	-	-	-	-	-
Sub-Total					9,300	11,200
TOTAL					54,700	68,500
Overhead & Profit 33%					20,600	22,600
TOTAL					75,300	91,100

TABLE 8-7-2 CONSTRUCTION COST

Section 1
Distance 22.0 km

(LS in 1977 Price)

	Unit	Unit Price Economic	Unit Price Financial	Quantity	Economic Cost	Financial Cost
A. Earthwork and Pavement						
1. Clearing	m^2	0.042	0.046	786,180	33,400	36,500
2. Earthwork fill	m^3	0.649	0.789	317,436	266,200	250,600
3. Cutting	m^3	0.728	0.883	103,521	75,400	91,400
4. Ditch cutting	m^3	0.115	0.126	183,385	21,000	23,100
5. Preparation of formation	m^2	0.104	0.125	132,000	13,800	16,500
6. Slope protection	m^3	0.374	0.457	136,855	51,200	62,500
7. Subbase	m^3	2.637	3.480	39,138	103,200	136,200
8. Base	m^3	2.784	3.671	26,400	73,500	96,900
9. Prime coat	T	90.91	127.27	198	18,000	25,200
10. Surface (DBST)	m^2	0.559	0.751	132,000	73,800	99,200
11. Shoulder	m^3	1.941	2.538	11,385	22,100	28,900
Sub-Total					691,600	867,000
B. Structures						
12. Bridge 9.0 x 1	U	10,460	12,570	3	31,400	37,700
9.0 x 3	U	26,400	31,850	2	52,800	63,700
Sum				5	84,200	101,400
13. Box Culvert						
2.0 x 1.5 2 cells	U	4,600	5,500	1	4,600	5,500
2.0 x 1.5 3 cells	U	6,200	7,450	2	12,400	14,900
Sum				3	17,000	20,400
14. Pipe ø 1.0 x 1	U	1,130	1,330	7	7,900	9,300
ø 0.6	U	23	27.5	117	2,700	3,200
Sum				124	10,600	12,500
Sub Total					111,800	134,300
TOTAL					803,400	1,001,300
Overhead & Profit					300,400	330,400
TOTAL					1,103,800	1,331,700

TABLE 8-7-3 CONSTRUCTION COST

ANNEX VIII-7

Section 2

Distance 22.0 km

(LS in 1977 Price)

	Unit	Unit Price Economic	Unit Price Financial	Quantity	Economic Cost	Financial Cost
A. Earthwork and Pavement						
1. Clearing	m^2	0.042	0.046	758,847	32,100	35,100
2. Earthwork fill	m^3	0.649	0.789	224,647	145,900	177,200
3. Cutting	m^3	0.707	0.858	13,865	9,800	11,900
4. Ditch cutting	m^3	0.114	0.125	195,620	22,300	24,500
5. Preparation of formation	m^2	0.104	0.125	132,000	13,800	16,500
6. Slope protection	m^3	0.374	0.457	103,680	38,800	47,400
7. Subbase	m^3	2.637	3.480	39,138	103,200	136,200
8. Base	m^3	2.784	3.671	26,400	73,500	96,900
9. Prime coat	T	90.91	127.27	198	18,000	25,200
10. Surface (DBST)	m^2	0.559	0.751	132,000	73,800	99,200
11. Shoulder	m^3	1.941	2.538	11,385	22,100	28,900
Sub-Total					553,300	699,000
B. Structures						
12. Bridge 7.0 x 2	U	14,700	17.600	1	14,700	17,600
9.0 x 1	U	10,400	12,500	2	20,800	25,000
Sum				3	35,500	42,600
13. Box Culvert 2.0 x 1.5 2 cells	U	4,650	5.600	2	9,300	11,200
14. Pipe ø 1.0 x 1	U	1,100	1,300	2	2,200	2,600
ø 0.6	U	23	27.5	118	2,700	3,200
Sum				120	4,900	5,800
Sub Total					49,700	59,600
TOTAL					603,000	758,600
Overhead & Profit					227,600	250,300
TOTAL					830,600	1,008,900

TABLE 8-7-4 CONSTRUCTION COST

Section 3
Distance 20.4 km

(LS in 1977 Price)

	Unit	Unit Price Economic	Unit Price Financial	Quantity	Economic Cost	Financial Cost
A. Earthwork and Pavement						
1. Clearing	m^2	0.042	0.046	692,161	29,300	32,000
2. Earthwork fill	m^3	0.649	0.789	187,163	121,500	147,600
3. Cutting	m^3	0.723	0.872	20,758	15,000	18,100
4. Ditch cutting	m^3	0.114	0.126	177,007	20,300	22,300
5. Preparation of formation	m^2	0.104	0.124	122,400	12,700	15,200
6. Slope protection	m^3	0.374	0.456	88,769	33,200	40,500
7. Subbase	m^3	3.373	4.456	36,292	122,400	161,700
8. Base	m^3	3.510	4.637	24,480	85,900	113,500
9. Prime coat	T	90.76	126.63	184	16,700	23,300
10. Surface (DBST)	m^2	0.563	0.796	122,400	72,600	37,400
11. Shoulder	m^3	1.942	2.538	10,557	20,500	26,800
Sub-Total					550,100	698,400
B. Structures						
12. Bridge 7.0 x 2	U	14,800	17,800	1	14,800	17,800
9.0 x 2	U	18,200	21,900	1	18,200	21,900
Sum				2	33,000	39,700
13. Box Culvert	U	-	-	-	-	-
14. Pipe ø 1.0 x 1	U	1,130	1,330	7	7,900	9,300
ø 1.0 x 3	U	2,700	3,200	1	2,700	3,200
ø 0.6	U	23	27.5	105	2,400	2,900
Sum				113	13,000	15,400
Sub Total					46,000	55,100
Total					596,100	753,500
Overhead & Profit					226,100	248,600
TOTAL					822,200	1,002,100

TABLE 8-7-5 CONSTRUCTION COST

Section 4
Distance 20.1 km

(LS in 1977 Price)

	Unit	Unit Price Economic	Unit Price Financial	Quantity	Economic Cost	Financial Cost
A. Earthwork and Pavement						
1. Clearing	m^2	0.042	0.046	699,475	29,600	32,300
2. Earthwork fill	m^3	0.649	0.789	245,264	159,200	193,400
3. Cutting	m^3	0.731	0.887	272,773	199,500	241,900
4. Ditch cutting	m^3	0.113	0.124	138,144	15,600	17,100
5. Preparation of formation	m^2	0.104	0.124	120,600	12,500	14,900
6. Slope protection	m^3	0.374	0.457	114,080	42,700	52,200
7. Subbase	m^3	3.373	4.458	35,758	120,600	159,400
8. Base	m^3	3.512	4.639	24,120	84,700	111,900
9. Prime coat	T	91.16	127.62	181	16,500	23,100
10. Surface (DBST)	m^2	0.593	0.795	120,600	71,500	95,900
11. Shoulder	m^3	1.942	2.538	10,402	20,200	26,400
Sub-Total					772,600	968,500
B. Structures						
12. Bridge 7.0 x 1	U	8,900	10,670	3	26,700	32,000
13. Box culvert 2.0 x 1.5 1 cell	U	2,900	3,500	1	2,900	3,500
14. Pipe ø 1.0 x 1	U	1,130	1,330	7	7,900	9,300
ø 1.0 x 2	U	1,970	2,330	3	5,900	7,000
ø 0.6	U	23	27	100	2,300	2,700
Sum				110	16,100	19,000
Sub Total					45,700	54,500
Total					818,300	1,023,000
Overhead & Profit					306,900	337,600
TOTAL					1,125,200	1,360,600

TABLE 8-7-6 CONSTRUCTION COST ANNEX VIII-7

Section 5
Distance 24.8 km

(LS in 1977 Price)

	Unit	Unit Price Economic	Unit Price Financial	Quantity	Economic Cost	Financial Cost
A. Earthwork and Pavement						
1. Clearing	m^2	0.042	0.046	881,777	37,400	40,800
2. Earthwork fill	m^3	0.649	0.789	332,611	215,900	262,400
3. Cutting	m^3	0.731	0.887	389,703	285,000	345,700
4. Ditch cutting	m^3	0.114	0.126	171,104	19,600	21,600
5. Preparation of formation	m^2	0.104	0.124	148,800	15,400	18,400
6. Slope protection	m^3	0.468	0.581	154,877	72,500	90,000
7. Subbase	m^3	4.832	6.401	44,120	213,200	282,400
8. Base	m^3	4.973	6.583	29,760	148,000	195,900
9. Prime coat	T	92.37	128.70	223	20,600	28,700
10. Surface (DBST)	m^2	0.661	0.884	148,800	98,400	131,600
11. Shoulder	m^3	2.673	3.506	12,834	34,300	45,000
Sub-Total					1,160,300	1,462,500
B. Structures						
12. Bridge		-	-	-	-	-
13. Box culvert 2.0 x 1.5 1 cell	U	3,010	3,640	9	27,100	32,700
14. Pipe ø 1.0 x 1	U	1,140	1,340	5	5,700	6,700
ø 1.0 x 2	U	2,000	2,350	2	4,000	4,700
ø 1.0 x 3	U	2,750	3,250	2	5,500	6,500
ø 0.6	U	23	28	125	2,900	3,500
Sum				134	18,100	21,400
Sub Total					45,200	54,100
Total					1,205,500	1,516,600
Overhead & Profit					455,000	500,500
TOTAL					1,660,500	2,017,100

TABLE 8-7-7 CONSTRUCTION COST

ANNEX VIII-7

Section 6

Distance 22.15 km

(LS in 1977 Price)

	Unit	Unit Price Economic	Unit Price Financial	Quantity	Economic Cost	Financial Cost
A. Earthwork and Pavement						
1. Clearing	m^2	0.042	0.046	768,151	32,400	35,400
2. Earthwork fill	m^3	0.649	0.789	268,296	174,200	211,600
3. Cutting	m^3	0.729	0.883	107,311	78,200	94,800
4. Ditch cutting	m^3	0.113	0.124	139,310	15,800	17,300
5. Preparation of formation	m^2	0.104	0.124	132,900	13,800	16,500
6. Slope protection	m^3	0.466	0.578	66,840	31,100	38,600
7. Subbase	m^3	4.832	6.401	39,405	190,400	252,200
8. Base	m^3	4.974	6.584	26,580	132,200	175,000
9. Prime coat	T	91.50	127.50	200	18,300	25,500
10. Surface (DBST)	m^2	0.661	0.883	132,900	87,800	117,300
11. Shoulder	m^3	2.670	3.500	11,463	30,600	40,100
Sub-Total					804,800	1,024,300
B. Structures						
12. Bridge		-	-	-	-	-
13. Box culvert						
2.0 x 1.5 1 cell	U	2,900	3,500	1	2,900	3,500
2.0 x 1.5 2 cells	U	4,600	5,500	1	4,600	5,500
Sum				2	7,500	9,000
14. Pipe ø 1.0 x 1	U	1,150	1,350	11	12,600	14,900
ø 0.6	U	23	27.5	102	2,500	3,000
Sum				119	15,100	17,900
Masonry	m^2	0.908	1.006	52,885	48,200	53,200
Sub Total					70,800	80,100
Total					875,600	1,104,400
Overhead & Profit					331,300	364,400
TOTAL					1,206,900	1,468,800

TABLE 8-7-8 CONSTRUCTION COST

ANNEX VIII-7

Access D

Distance 1.53 km

(LS in 1977 Price)

	Unit	Unit Price Economic	Unit Price Financial	Quantity	Economic Cost	Financial Cost
A. Earthwork and Pavement						
1. Clearing	m^2	0.040	0.043	60,467	2,400	2,600
2. Earthwork fill	m^3	0.619	0.745	7,917	4,900	5,900
3. Cutting	m^3	0.697	0.833	5,163	3,600	4,300
4. Ditch cutting	m^3	0.094	0.094	4,253	400	400
5. Preparation of formation	m^2	0.076	0.087	9,180	700	800
6. Slope protection	m^3	0.270	0.321	3,740	1,000	1,200
7. Subbase	m^3	3.301	4.357	3,787	12,500	16,500
8. Base	m^3	3.431	4.521	1,836	6,300	8,300
9. Prime coat	T	84.62	115.38	13	1,100	1,500
10. Surface (DBST)	m^2	0.560	0.755	9,180	5,100	6,900
11. Shoulder	m^3	1.820	2.400	1,710	3,100	4,100
Total					41,100	52,500
Overhead & Profit					15,800	17,300
TOTAL					56,900	69,800

TABLE 8-7- 9 CONSTRUCTION COST

ANNEX VIII-7

Access F

Distance 1.04 km

(LS in 1977 Price)

	Unit	Unit Price Economic	Unit Price Financial	Quantity	Economic Cost	Financial Cost
A. Earthwork and Pavement						
1. Clearing	m^2	0.037	0.038	43,591	1,600	1,700
2. Earthwork fill	m^3	0.620	0.750	9,197	5,700	6,900
3. Cutting	m^3	-	-	-	-	-
4. Ditch cutting	m^3	0.060	0.060	3,325	200	200
5. Preparation of formation	m^2	0.064	0.080	6,240	400	500
6. Slope protection	m^3	0.393	0.477	3,562	1,400	1,700
7. Subbase	m^3	4.779	6.294	2,574	12,300	16,200
8. Base	m^3	4.808	6.330	1,248	6,000	7,900
9. Prime coat	T	86.02	118.28	9.3	800	1,100
10. Surface (DBST)	m^2	0.625	0.817	6,240	3,900	5,100
11. Shoulder	m^3	2.410	3.182	1,163	2,800	3,700
Total					35,100	45,000
Overhead & Profit					13,500	14,900
TOTAL					48,600	59,900

TABLE 8-8 QUANTITIES OF MATERIALS TO BE PROCURED

1.	Bitumen	13,000 t
2.	Cement	2,700 t
3.	Reinforcing Bar	480 t
4.	Diesel	3,560,000 Gal.
5.	Lublicant	97,000 Gal.
6.	Grease	58,000 kg
7.	Gasoline	3,800 Gal.
8.	Filler	5,000 t
9.	Concrete Pipe	
	ϕ 1,000 m/m	770 m
	ϕ 600 m/m	740 m
10.	Steel Form	14,000 m^2

TABLE 8-9 COST OF DETAILED DESIGN

(Net of Customs and Taxes)

			(LS)
(1)	Engineering Fees		
	a. Staff	2,000 LS x 9 Mon x 10 Man =	180,000
	b. Assistants	300 LS x 6 Mon x 10 Man =	18,000
(2)	Traveling Allowances (Khartoum - Paris)		
	a. Traveling	500 LS x 16 Time =	8,000
	b. Per diem	240 LS x 90 Mon =	21,600
(3)	Field Investigations		
	a. Vehicles	1,000 LS x 8 Mon x 5 Vehi =	40,000
	b. Transport of Materials	=	3,400
	c. Machine for Survey	=	15,000
	d. Labourer	=	6,000
	e. Office and Lodge	=	32,000
(4)	Soil and Material Tests		
	a. Boring Test	=	10,000
	b. Other Test	=	6,000
(5)	Topographic Maps	=	22,000
(6)	Report and Drawings	=	18,000
	Total	=	380,000

TABLE 8-10 SCHEME FOR WORK ITEMS

	Item	Equipment	Output
1.	Clearing	1 D7G	3,000 m^2/d
2.	Normal Earthwork Filling (compacted)	2 D7G, 1 Motor Scraper (21 cu.yd.), 1 Motor Grader, 2 Tired Roller, 1 Water Tanker	1,000 m^3/d
3.	Cutting	1 D7G	500 m^3/d
4.	Preparation of Formation	1 D7G, 1 Motor Grader 2 Water Tanker	2,500 m^2/d
5.	Sub Base borrow to fill (compacted)	1 Excavator, 1 Motor Grader 2 Tired Roller, 2 Water Tanker	760 m^3/d
6.	Base (as above)	1 Excavator, 1 Motor Grader 2 Tired Roller, 2 Macadam Roller, 2 Water Tanker	760 m^3/d
7.	Prime Coat	1 Asphalt Distributor	16 T/d
8.	Double Bituminous Surface Treatment	1 Asphalt Distributor 2 Motor Grader, 4 Macadam Roller	5,000 m^2/d
9.	Slope Protection	1 Plate Compactor	200 m^2/d
10.	Shoulder	1 Motor Grader, 1 Tired Roller	500 m^3/d

Notes: 1) Annual working days are estimated at 260.

2) Working days for earthwork are 180 - 200.

3) Outputs are calculated by the capacity and the efficiency of each item of mechanical equipment.

TABLE 8-11 REQUIRED QUANTITY OF PRINCIPAL EQUIPMENT

Equipment		1980	1981	1982
Bulldozer D7G		13	14	14
Motor Grader 12'		7	7	7
Motor Scraper	21 cu.yd.	3	3	3
Tired Roller	15 t	7	7	7
Macadam Roller	10 t	6	6	6
Excavator	0.7 cu.yd.	2	2	2
Asphalt Distributor	4 t	2	2	2
Water Tanker	8 t	7	7	7
Wheel Loader	1.9 m^3	2	2	2
Crawler Drill		2	2	2
Crushing Plant	30 t/hr	2	2	2
Dump Truck	11 t	40	40	40

TABLE 8-12-1 ACQUISITION COST OF EQUIPMENT

(LS)

Equipment	Port Sudan CIF Price	Local Component	Import Duty and Taxes	Total	Daily rate As % of Cost
1. Bulldozer D7G with Blade	41 865	15 153	5 860	62 878	0.17
2. Bulldozer D8K with Blade & Ripper	65 000	23 450	10 660	99 110	0.17
3. 623B Motor Scraper (21 cu.yd.)	68 532	24 886	25 014	118 432	0.18
4. Motor Grader (blade width 12')	21 825	8 339	7 965	38 129	0.18
5. 225 Excavator (0.7 cu.yd.)	39 285	14 650	14 338	68 273	0.22
6. Wheel Loader W90 (1.9 m^3)	23 299	8 655	8 504	40 458	0.17
7. Soil Compactor WF22A	46 697	17 043	17 044	80 784	0.17
8. Tractor Shovel D45S (1.2 m^3)	14 459	5 561	5 278	25 298	0.18
9. Tired Roller(15 tons class)	10 454	3 597	5 385	19 436	0.21
10. Macadam Roller (10 tons class)	8 853	2 997	4 559	16 409	0.18
11. Dump Truck (11 tons)	11 499	3 857	7 072	22 428	0.17
12. Flatbed Truck (10 tons)	8 335	2 828	5 127	16 290	0.34
13. Water Tanker (8,000 ℓ)	8 730	2 957	5 370	17 057	0.18

ACQUISITION COST OF EQUIPMENT (Cont'd.)

(LS)

Equipment	Port Sudan CIF Price	Local Component	Import Duty and Taxes	Total	Daily rate As % of Cost
14. Fuel Tanker (8 tons)	9 127	3 086	5 612	17 825	0.18
15. Asphalt Distributor (4 tons)	12 064	4 040	7 419	23 523	0.18
16. Air Compressor (10.5 m^2/min.)	5 545	1 784	2 023	9 352	0.28
17. Crawler Drill CRF110	8 899	3 315	3 248	15 462	0.33
18. Generator 50HZ EG150	7 561	2 388	3 893	13 842	0.22
19. Concrete Mixer (0.4 m^3)	2 352	943	859	4 154	0.21
20. Concrete Vibrator ⌀2" 3/8	238	134	88	460	0.40
21. Crushing Plant (30 T/Hr)	51 587	15 676	18 829	86 092	0.11
22. Vibration Roller (2.5 tons)	3 621	1 296	1 864	6 781	0.21
23. Asphalt Plant (60 T/Hr)	55 556	20 444	20 280	96 280	0.14
24. Asphalt Finisher (2.4 ~ 4.5 m)	18 487	6 747	6 970	32 204	0.17
25. Plate Compactor WUP38	1 894	692	783	3 369	0.40
26. Truck Crane NK110	15 873	5 755	5 792	27 420	0.15

Source: The Study Team, June, 1977.

TABLE 8-12-2 COST OF ACQUISITION A D7G (CAT.)

A) Foreign Component

CIF Price	US$	LS
Bare Tractor	94,960	37,683
Angle Blade	10,540	4,182
Total A	105,500	41,865

B) Custom

4, 182 x 25%	1,046
Surcharge CIF x 5%	2,093
Quay Due 1.5%	628
Development Tax 5%	2,093
Total B	5,860

C) Local Component

Remittance CIF x 15%	6,280
Profit 20%	8,373
Transport and Miscellaneous	500
Total C	15,153
Total A + C	57,018
Total A + B + C	62,878

TABLE 8-13 BREAKDOWN OF COST NO. 1

Clearing and Stripping

Item	Foreign Component	Local Component	Tax Component	Total Cost
Equipment				
1 D7G	73.04	26.44	10.22	109.70
Labour				
1 Driver		2.00		2.00
1 Foreman		2.40		2.40
10 Labourers		9.60		9.60
Materials				
Diesel	4.25	9.03	2.38	15.66
Total	77.29	49.47	12.60	139.36
Output 3,000 m^2/day				
LS per m^2	0.026	0.016	0.004	0.046
Overhead & Profit LS per m^2 (33%)				
Foreign Contractor	0.010	0.004	0.001	0.015
Unit Price LS per m^2				
Foreign Contractor	0.036	0.020	0.005	0.061

Economic Cost LS 0.056 per m^2

TABLE 8-14 BREAKDOWN OF COST NO. 2
NORMAL EARTHWORK (Cut to Fill)

Item	Foreign Component	Local Component	Tax Component	Total Cost
Equipment				
2 D 7 G	146.08	52.88	20.44	219.40
1 Motor Scraper	122.24	44.39	44.61	211.24
1 Motor Grader	43.84	15.08	22.58	81.50
2 Tired Roller	38.56	14.73	14.07	67.36
2 Water Tanker	31.52	10.68	19.38	61.58
Labour				
8 Drivers		16.00		16.00
1 Foreman		2.40		2.40
12 Labourers		11.52		11.52
Materials				
Diesel	30.90	65.66	17.33	113.89
Total	413.14	233.34	138.41	784.89
Output 1,000 m^3/day				
LS per m^3	0.413	0.233	0.138	0.784
Overhead & Profit LS per m^3 (33%)				
Foreign Contractor	0.165	0.070	0.023	0.258
Unit Price LS per m^3				
Foreign Contractor	0.578	0.303	0.161	1.042

Economic Cost LS 0.881 per m^3

TABLE 8-15 HOURLY EQUIPMENT OWNERSHIP AND OPERATION COST

(ECONOMIC)

1977 Prices

LS 1.00 = US$2.52

Equipment: Bulldozer D7G HP 200

Item		Calculation	Number	Unit
I.	General Data			
	A. Type of Fuel		Diesel	
	B. Fuel Consumption		4.60	gal/hr
	C. Fuel Cost		0.312	LS/gal
	D. Economic Life		10,000	hours
	E. Economic Life		8	years
II.	Acquisition Costs			
	F. Total Cost CIF		41,865	LS
	G. Cost of Tires		-	LS
	H. Total Cost Less Tires	F - G	41,865	LS
III.	Hourly Ownership Costs			
	I. Depreciation	H/D	4.19	LS/hr
	J. Major Repairs and Overhaul	$\frac{0.75xHx0.975}{D}$	3.06	LS/hr
	K. Interest	$\frac{0.1xFx0.5625}{D/E}$	1.88	LS/hr
	L. Hourly Ownership Cost (Economic)	I + J + K	9.13	LS/hr
IV.	Hourly Operation Costs			
	M. Cost of Fuels	B x C	1.44	LS/hr
	N. Cost of Lubricants and Filters	0.15 x M	0.22	LS/hr
	O. Cost of Tires:		-	LS/hr
	a - Depreciation			
	b - Repairs			
	P. Operation Cost	M + N + O	1.66	LS/hr
V.	TOTAL ECONOMIC COST	L + P	10.79	LS/hr

TABLE 8-16 MAINTENANCE AND REPAIR COST (1983 - 2002)

(LS)

Year		Section 1	2	3	4	5	6	TOTAL
Distance (km)		24.0	22.0	21.93	20.1	24.8	23.19	136.02 km
a)	Maintenance and Repair							
1	1983	4,400	4,000	4,000	3,700	4,500	4,200	24,800
2	1984	"	"	"	"	"	"	24,800
3	1985	"	"	"	"	"	"	24,800
4	1986	"	"	"	"	"	"	24,800
5	1987	"	"	"	"	"	"	24,800
6	1988	"	"	"	"	"	"	24,800
7	1989	"	"	"	"	"	"	24,800
8	1990	78,800	72,200	72,000	66,000	81,400	76,100	446,500
9	1991	4,400	4,000	4,000	3,700	4,500	4,200	24,800
10	1992	"	"	"	"	"	"	24,800
11	1993	"	"	"	"	"	"	24,800
12	1994	3,200	2,900	2,900	2,700	3,300	3,000	18,000
13	1995	"	"	"	"	"	"	18,000
14	1996	"	"	"	"	"	"	18,000
15	1997	"	"	"	"	"	"	18,000
16	1998	"	"	"	"	"	"	18,000
17	1999	"	"	"	"	"	"	18,000
18	2000	"	"	"	"	"	"	18,000
19	2001	"	"	"	"	"	"	18,000
20	2002	"	"	"	"	"	"	18,000
	TOTAL	151,600	138,300	138,100	127,300	156,100	145,100	856,500
b)	Overlay							
	1993	386,300	354,700	352,700	323,700	400,100	373,100	2,190,600

ANNEX IX

TABLE 9-1 TRAFFIC COMPOSITION ON KHARTOUM - WAD MEDANI ROAD (24 HOURS)

Station	12 Km from Khartoum			9 Km from Khartoum			94 Km from Khartoum		
Direction	Khartoum --- Wad Medani			Khartoum --- Wad Medani			Khartoum --- Wad Medani		
Date of Survey	30 May 1977 2)			21 - 27 Aug. 1976 1)			21 - 27 Aug. 1976 1)		
Type of Vehicle	ADT	Percent		ADT	Percent		ADT	Percent	
Passenger Vehicles									
Car.Taxi	379	14.0	-	668	26.8	-	65	14.4	-
4 Wheel Drive	203	7.5	-	251	10.1	-	46	10.2	-
Box	208	7.7	-	-	-		-	-	-
Sub Total	790	29.2	-	919	36.9	-	111	24.6	-
Bus (Large)	219	8.1	-	342	13.8	-	100	22.1	-
Bus (Medium Small)	222	8.2	-	107	4.3	-	6	1.3	-
Sub Total	441	16.3	-	449	18.1	-	106	23.4	-
Total	1,231	45.5	-	1,368	55.0	-	217	48.0	-
Lorries									
Van/pick-up	349	12.9	-	479	19.2	-	44	9.7	-
Medium Truck	815	30.1	73.4	588	23.6	90.6	173	38.3	91.6
Heavy Truck	81	3.0	7.3	32	1.3	7.3	14	3.1	5.0
Truck Trailer	214	7.9	19.3	22	0.9	2.1	4	0.9	3.4
Total	1,459	53.9	100.0	1,121	45.0	100.0	235	52.0	100.0
Other	16	0.6	-	-	-	-	-	-	-
Grand Total	2,706	100.0	-	2,489	100.0	-	452	100.0	-

Sources: 1) RBPC, 1977

2) JICA's project study team, May 30, 1977.

ANNEX IX-2 DIVERSION TRAFFIC AND ITS BENEFITS

When the construction of the project road is completed, passengers and goods carried by railways will be diverted to vehicles on the road. Whether an individual or his goods will divert to road use or not will be determined by assessing rates, handling charges, travel time, delays, etc. of road service versus rail service. When the diversion is realized the economic benefit is measured not by the margin of rates between the two modes, but by the margin of transport costs between them. There are other surpluses or losses resulting from the diversion, but since they are difficult to quantify in terms of economic cost, they are not included in the estimate of economic benefits.

In the case of railways, the economic cost is calculated by the working expense on the existing stock which was invested in the past. No capital investment is assumed but maintenance work is taken into account. While in the case of the road, both working expense and capital cost are estimated for the transport of diverted traffic, in which the capital cost is measured by vehicle depreciation. The capital cost and the maintenance cost of the project road are not included in the analysis of the diversion benefit. These costs are considered in the overall benefit cost streams of the project. It is considered that the long distance traffic on the railways between Nyala and Khartoum will be little influenced by this road project.

2.1 Passengers

i. The Transport Cost of Railway Passengers

The working expense of railways is estimated by the following

Table 9-2-1,in which the economic cost of railways between El Obeid and Khartoum is developed as LS 0.005 per passenger - km.

ii. The Cost of Passengers by Vehicles

It is assumed all passengers who divert to vehicle use on roads will be carried by bus. One bus will transport 35 persons out of a total of 44 seats. The depreciation cost of buses is included in the running cost on the project roads. The cost of the road itself is already included in the primary project cost.

iii. The Value of Time of Passengers

Annual cash income is estimated at LS 155 for a rural area family. Although no figures are available for families in the urban area, it is estimated that the average lies between LS 200 and 250. Taking the figure of LS 155, the following calculation is made for the time value per passenger.

$$155 \div 5 \text{ persons} \div 365 \text{ days} \div 24 \text{ hours}$$
$$= 0.0035 \text{ per person per hour.}$$

However, it is difficult to determine to what extent the time saved is utilized for other economic activities which would contribute to increasing the scale of the Sudanese economy. Therefore, savings in travel time are not evaluated in the benefits of the project.

ANNEX IX-2

TABLE 9-2-1 WORKING EXPENSE OF RAILWAYS

(LS)

	A	B	C	D	E	F
				The Project Area		
Class	Revenue per Passenger - Km 1)	Working Expense 1975/76 2)	Working Expense per Passenger - Km 3)	Number of Passengers per Train 4)	Working Expense per Train - Km	Average Working Expense per Person
Sleeper	0.022	386,133	0.024	[26]	0.624	
1st	0.015	675,734	0.015	[64]	0.960	4.806
2nd	0.007	772,267	0.007	[96]	0.672	+ 961
3rd	0.004	1,448,000	0.004	[225]	0.900	= 0.005
4th	0.003	1,544,534	0.003	[550]	1.650	
Total or Average	0.004	4,826,669	0.004	[961]	4.806	

Notes: 1) Taken from Table 9-2-10.

2) Working expense is divided into five classes by the percent of revenue by class.

3) Calculated by dividing Column B by the figures of passenger - Km in Table 9-2-10.

4) Taken from Table 6-19, Annex VI-20. Figures are the number of passengers, not LS.

TABLE 9-2-2 BUS OPERATING COST

(LS)

Working Cost of a Bus per Km 1)		Bus Working Cost per Km per Passenger	Bus Working Cost Between El Obeid and Khartoum per per Passenger (700 Km) 2)	Bus Fare Between El Obeid and Khartoum per Passenger on Paved Road 3)
1. Labour	0.0146	0.0714	700 x 0.071	
2. Fuel	0.0180	-	= 49.98	
3. Maintenance	0.0148	35	49.98 + 10	2.460
4. Overhead etc.	0.0101	= 0.0021	= 59.98	
5. Depreciation	0.0139		59.98 ÷ 35	
Total	0.0714		= 1.714	

Notes: 1) Taken from Table VI-15.

2) One night stay of a driver and an assistant costs LS 10. Their meals, overtime charges, etc. are included in the above.

3) The bus fare is determined by applying the existing bus fare on the paved road of Khartoum - Wad Medani of 185 Km.

0.65/185 x 700 = 2.459

iv. Rail Passengers and Their Diversion

Table VI-8 shows the movement of rail passangers among the zones. Generally, short distant travellers choose vehicles on roads because of the frequency of services. In the project area, the passengers are expected to make the same choice and divert to buses. The number of passengers who divert to buses are 60 for El Obeid - Um Ruaba, 5 for El Obeid - Rahad, and 53 for Rahad - Um Ruaba. This is shown in Table 9-2-5.

Long distant travellers on railways have their origins and destinations distributed over the entire country. They are grouped into two pairs: El Obeid - Khartoum of 147 passengers and Rahad - Khartoum of 39, and are shown in Table 9-2-5. The passengers in 3rd and 4th class must pay higher prices for buses than for rail fares, Therefore, they will not divert to buses under the assumption established in this study.

v. Diverted Benefits and the Number of Buses

It is likely that passenger volume on railways in the project area will remain about the same for the coming several years. The reasons are that train seats are occupied to near capacity, permitting no room for additional travellers, and the trend in the past several years shows no increase in the number of passengers. The growth rate of diverted passengers is the same as that for normal traffic. They are applied for the years after 1983. Tables 9-2-3 and 9-2-4 are summaries of Table 9-2-5.

TABLE 9-2-3 NUMBER OF BUSES FOR DIVERTED PASSENGERS PER DAY

Year	El Obeid	Rahad	Um Ruaba	Average
(1977)	(7.5)	(8.5)		(8.0)
1983	7.5	8.5		8.0
1992	13.8	15.6		14.7
2002	22.5	25.4		24.0

ANNEX IX-2

TABLE 9-2-4 ECONOMIC BENEFITS OF DIVERTED PASSENGERS

(LS)

Year	In 1977 Price	Discounted to 1978 at 10%
(1979)	108,138	-
1983	108,138	67,154
1992	198,758	52,333
2002	323,578	32,843

TABLE 9-2-5 TRANSPORT COST OF PASSENGERS

ANNEX IX-2

Section	Class	Train Fares by Class per Passenger (LS)	Bus Fares per Passenger (LS)	Economic Cost per Passenger: Train (1) (LS)	Economic Cost per Passenger: Bus (2) (LS)	Balance (3)=(1)-(2) (LS)	No. of Diverted Passengers by Class	Benefit (3)x365x No. of Diverted Passengers (LS)	No. of Buses
		147 Km	135 Km						
El Obeid	Sleeper	2.500					4.5		
- Um Ruaba	1st	2.100					5.0		
	2nd	1.050	0.475	0.7350	0.2835	0.4515	10.6		
	3rd	0.490					28.8		
	4th	0.380					10.7		
							Total 59.6	9,821	1.7
		69 Km	68 Km						
El Obeid	Sleeper	2.500					-		
- Rahad	1st	1.170					0.1		
	2nd	0.595	0.239	0.345	0.1428	0.2022	-		
	3rd	0.285					2.4		
	4th	0.220					2.4		
							Total 4.9	362	0.1
		78 Km	67 Km						
Rahad	Sleeper	2.500					0.4		
- Um Ruaba	1st	1.125					-		
	2nd	0.565	0.235	0.390	0.1407	0.2493	4.0		
	3rd	0.265					29.4		
	4th	0.210					19.2		
							Total 53.0	4,823	1.5
		627 Km	700 Km						
El Obeid	Sleeper	17.000					29.6		
- Khartoum	1st	10.200					33.0		
	2nd	5.100	2.460	3.135	1.714	1.412	84.3		
	3rd	2.380					-		
	4th	1.840					-		
							Total 146.9	76,192	4.2
		558 Km	642 Km						
Rahad	Sleeper	12.600					9.6		
- Khartoum	1st	8.400					4.7		
	2nd	4.200	2.256	2.790	1.600	1.190	24.7		
	3rd	1.960					-		
	4th	1.515					-		
							Total 39.0	16,940	1.1
						GRAND TOTAL:	303.4	LS 108,138	8.6

2.2 Freight

i. The Transport Cost by Railways

The economic cost of freight transportation by railways is estimated in Table 9-2-6 by applying the Sudan Railways Corporation's statistical data as shown in Tables 9-2-11 and 12. The current tariffs for major commodities and the charges on access transport and warehousing were studied and are shown in Table 9-2-7.

ANNEX IX-2

TABLE 9-2-6 ECONOMIC COST OF RAILWAYS FOR CARGOES, 1975/1976

(Unit: LS)

	A	B	C	D	E	F
	Travel Distance per ton 1)	Revenue per ton-km 1)	Yearly Working Expense ('000) 2)	Working Expense per ton-km 3)	Working Expense El Obeid-Khartoum (689 km) per ton	Working Expense El Obeid-Port Sudan (1476 km) per ton
Goods	(981)	0.010				
Livestock	(807)	0.014				
Total	(981)	0.010	21.988	0.008	5.512	11.808

Notes: 1) From Table 9-2-11

2) From Table 9-2-12

3) D = 21,988,000 ÷ 2,620,723,000 = 0.008

TABLE 9-2-7 RAILWAY TARIFF

		The No. of Exceptional Rates in the Relevant Table [1]	Application of Scale 80% Loading	Tariff per Ton [2]	Loading and Unloading Labour Charge per-Ton [3]	Transport Cost on Access 4 km per-Ton by Horse-Wagon	Additional Storage Charge due to Train Delays	Total Tariff on the User
1.	Groundnuts	5	24	13.30	0.55			15.370
2.	Sesame	14	40	19.70	0.55			21.770
3.	Gum Arabic	15	41	20.20	0.55			22.270
4.	Watermelon Seed	-	26	13.90	0.83			16.250
5.	Oil Cakes	-	26	13.90	0.55			15.970
6.	Karkadeh	-	26	13.90	1.65		LS 0.20 x 7 days	17.070
7.	Sugar	20	37	18.20	0.55	0.12		20.270
8.	Salt	-	26	13.90	0.55		= LS 1.40/ton	15.970
9.	Cement	19	50	25.20	0.55			27.270
10.	Onions	-	26	5) 7.20	0.55			9.270
11.	Flour	3	12	5) 5.10	0.55			7.170
12.	Dura	8	18	5) 5.90	0.55			7.970
13.	Cotton, American	41	41	6) 18.90	1.10			21.520
14.	Cotton Seed	2	23	6) 12.10	0.83			14.450
15.	Others [4]	-	26	7.20	0.55			9.270

Notes: 1) From The Sudan Railway "Tariff Table 1975"

2) Rates per ton between El Obeid and Port Sudan of 1,476 km are calculated by the table in 1).

3) Loading and unloading charges are determined by the payment to the labours in El Obeid crop market, where LS 0.025 per sac is paid for loading or unloading.
One sac averages two kantars (200 lb)
1 kg = 2.2 lb 1 ton = 2,200 lb = 22 kantars = 11 sacs
Loading and unloading of 1 ton = 0.025 x 11 x 2 = LS 0.55

4) Others are carried between El Obeid and Khartoum.

5) Between El Obeid and Khartoum of 690 km.

6) Between Semeih and Port Sudan of 1,385 km.

TABLE 9-2-8 WORKING EXPENSE OF TRUCKS

	Working Expense of 11-ton Capacity Truck on Paved Road (LS/km) [1]	Working Expense (per ton km) [2]	Working Cost on El Obeid-Khartoum Road of 700 km [3]	Working Cost on El Obeid-Port Sudan Road of 1,550 km [3]	Working Cost on Semeih-Port Sudan Road of 1,450 km [3]
Labour	0.01563	0.11227/8.0 = 0.01403	78.589	174.019	162.792
Fuel	0.02300		10.000	20.000	20.000
Maintenance	0.02806		4.400 [4]	4.400 [4]	4.400 [4]
Overhead, etc.	0.01958		92.989 per truck	198.419 per truck	187.192 per truck
Depreciation	0.0260		11.624 per ton	24.802 per ton	23.399 per ton
Total:	0.11227				

Notes: 1) Taken from Table VI-4

2) 0.11227 ÷ 8.0 = 0.01403. The traffic study in the project area shows that the loading rate in terms of tonnage is approximately 80%. It is applied here to estimate economic cost per ton.

3) When the distance of truck operation is longer, the working cost will increase because additional expense is necessary to cover the allowances for items such as overtime charges, meals, and over-night stops of drivers and assistants. A one night stop is assumed for the El Obeid-Khartoum trip, and a two night stop for the El Obeid-Port Sudan trip. The former costs LS 10 and the latter LS 20. It is assumed the whole road will be paved in 1982.

4) Loading and unloading costs are estimated for each trip as LS 0.55/ton and LS 4.4/truck.

TABLE 9-2-9 TRUCK FARE ON THE PROJECT ROADS

		Rates per Kantar	Rates per Ton 22 Kantar = 1 Ton (LS/ton)	Loading and Unloading Charge per Ton (LS)	Rates Loading and Unloading Charge per Ton (LS)
1. Groundnuts		1.20	26.4	0.55	26.95
2. Sesame		1.40	30.8	0.55	31.35
3. Gum Arabic		1.60	35.2	0.55	35.75
4. Watermelon Seed		1.20	26.4	0.83	27.23
5. Oil Cakes		1.20	26.4	0.55	26.95
6. Karkadeh		1.40	30.8	1.65	32.45
7. Sugar		2.00	44.0	0.55	44.55
8. Salt		2.00	44.0	0.55	44.55
9. Cement		2.85	62.7	0.55	63.25
10. Onions	1)	0.70	15.4	0.55	15.95
11. Flour	1)	0.70	15.4	0.55	15.95
12. Dura	1)	0.70	15.4	0.55	15.95
13. Cotton, American	2)	1.20	26.4	0.55	26.95
14. Cotton, Seed	2)	1.20	26.4	0.83	27.23
15. Others	1)	0.70	15.4	0.55	15.95

Source: Interviews in the project area.

Note : All goods are carried between El Obeid and Port Sudan except 1) El Obeid-Khartoum and 2) Semeih-Port Sudan.

ii. Transport Cost by Trucks

The vehicle running cost is studied in 6.04, CHAPTER 6. The details of the running cost of a heavy truck is again presented in the previous Table 9-2-8.They are presented in terms of economic cost. Table 9- 2-9 shows the freight charges by truck operator assuming a paved road between El Obeid and Khartoum.

iii. Diversion of Goods

The shipper of goods selects a mode of transport by comparing the price for alternative modes. Tables 9-2-7 and 9-2-9 show the charge per ton for each commodity by railway and truck, respectively. They show that it is less expensive by railway than by truck. Tables 9-2-6 and 9-2-8 show the economic cost of transport by railway and truck, respectively. Again, the economic transport cost is less by railway than by truck, under the relevant assumption. By comparing the monetary transport charge, it is quite likely that there will be little or no diversion to roads.

However, trucks on the existing roads carry a considerable quantity of goods throughout the year as shown in Annex VI-16. The owners of these goods send them by truck in order to better meet loading times at Port Sudan, or to avoid loss of time and possible loading and unloading damage at rail stations. Thus, when the road is improved, some diversion from railway service may occur due to the above factors, despite higher transport cost. These plus factors must be evaluated on non-quantifiable benefits and are not, therefore, included in the economic benefit stream.

TABLE 9-2-10 TRAFFIC VOLUMES BY RAILWAYS, 1974/75 AND 1975/76

	Passengers			Passenger - km			Revenue		
	1974/75	1975/76		1974/75	1975/76		1974/75	1975/76	
				('000)			(LS '000)		
1. Passengers									
Sleeping Supp.	24,694	29,999	(1)	13,412	16,226	(1)	302	365	(8)
1st Class	79,366	111,140	(4)	38,218	44,157	(4)	563	662	(14)
2nd Class	233,862	232,062	(8)	98,306	114,131	(10)	735	785	(16)
3rd Class	865,955	970,923	(32)	361,521	417,125	(36)	1,255	1,460	(30)
4th Class	1,742,673	1,725,081	(55)	590,409	575,019	(49)	1,574	1,553	(32)
Total	2,946,550	3,069,205	(100)	1,101,866	1,166,658	(100)	4,429	4,824	(100)
	Goods in tons			Goods ton - km			Revenue		
	1974/75	1975/76		1974/75	1975/75		1974/75	1975/76	
				('000)					
2. Goods and Animals									
Export	643,933	815,426	(30)						
Import	1,311,742	1,494,409	(56)						
Local	433,661	346,282	(13)						
Total	2,389,336	2,656,117	(99)	2,159,739	2,607,450		18,359	26,175	
Livestock (Head)	(397,000)	(242,000)							
in Equivalent tons	10,922	16,439	(1)	15,640	13,273				
Total	2,400,258	2,672,556	(100)	2,175,379	2,620,723		18,559	26,355	

Source: Sudan Railways Corporation, Ibid.

Note : ( ) shows a percentage composit.

TABLE 9-2-11 WORKING EXPENSES OF RAILWAYS, 1974/75 AND 1975/76

(LS)

	1974/75	1975/76
Locomotives Running	6,455,593	6,561,119
Personnel	1,622,350	1,811,036
Fuel	4,443,197	4,152,862
Stores	157,786	301,036
Water Supply	232,260	296,185
Rolling Stock Maintenance	6,311,930	7,551,324
Superintendence	364,116	439,692
Locomotives	3,436,451	4,004,425
Coaching & Freight	2,511,363	3,107,207
Traffic	4,421,365	4,796,294
Personnel	3,763,947	3,899,152
Others	657,418	897,142
Way and Works	3,873,134	4,489,564
Superintendence	419,569	487,012
Permanent Way, Buildings	2,359,431	2,807,408
Signals, Telegraph	253,005	272,063
Bridges, Roads, etc.	542,146	422,731
Others	298,983	500,350
General Charges	3,429,965	3,416,527
Personnel	3,429,965	2,482,982
Others	-	933,545
Total	24,491,987	26,814,828

Source: Sudan Railways Corporation Annual Report, 1975-76.

Note : Depreciation charges are not included in this table. The statistics show the percentage shares of working expense, including depreciation, are 19% for passenger service and 81% for goods in 1974/75, 18% and 82% respectively, in 1975/76. In 1975/76 the working expense was calculated as follows:

Passengers	(18%)	4,826,669
Goods	(82%)	21,988,159
Total	(100%)	26,814,828

TABLE 9-2-12 RAILWAYS OPERATIONS, 1974/75 AND 1975/76

	Unit	1974/75	1975/76
1. Passengers			
Train - Km		1,114,000	1,163,000
Vehicle - Km		29,365,000	28,687,000
Average Veh./Tr.	No.	26.4	24.7
Passengers	No.	2,946,550	3,069,205
Passenger - Km in '000		1,101,866	1,166,658
Revenues	LS	4,429,000	4,824,000
2. Goods			
Train - Km		4,860,000	5,341,000
Vehicle - Km		132,291,000	140,961,000
Average Veh./Tr.	No.	27.2	26.3
Goods carried	Ton	2,400,258	2,672,556
Goods - Ton - Km in '000		2,175,379	2,620,723
Revenues	LS	18,559,000	26,355,000

Source: Sudan Railways Corporation, Ibid.

TABLE 9-3-1 EL OBEID - UM RUABA ROAD
AVERAGE NUMBER OF VEHICLE BY TYPE (ADT)

Traffic by Year		Type of Vehicle: Small Vehicles	Medium Trucks	Large Trucks	Buses	Total
Plan 1						
1983	Normal Traffic	7.5	165.7	20.4	1.2	194.8
	Diverted Traffic	-	-	-	8.0	8.0
	Generated Traffic	18.0	-	-	-	18.0
	Total	25.5	165.7	20.4	9.2	220.8
1992	Normal Traffic	13.8	257.7	84.4	2.2	358.1
	Diverted Traffic	-	-	-	14.7	14.7
	Generated Traffic	33.1	-	-	-	33.1
	Total	46.1	257.7	84.4	16.9	405.9
2002	Normal Traffic	22.5	353.5	203.7	3.6	583.3
	Diverted Traffic	-	-	-	24.0	24.0
	Generated Traffic	53.9	-	-	-	53.9
	Total	76.4	353.5	203.7	27.6	661.2
Plan 2						
1983	Normal Traffic	7.5	165.2	20.4	1.4	194.5
	Diverted Traffic	-	-	-	8.0	8.0
	Generated Traffic	18.0	-	-	-	18.0
	Total	25.5	165.2	20.4	9.4	220.5
1992	Normal Traffic	13.8	256.9	84.4	2.5	357.6
	Diverted Traffic	-	-	-	14.7	14.7
	Generated Traffic	33.1	-	-	-	33.1
	Total	46.9	256.9	84.4	17.2	405.4
2002	Normal Traffic	22.5	352.2	203.7	4.0	582.4
	Diverted Traffic	-	-	-	24.0	24.0
	Generated Traffic	53.9	-	-	-	53.9
	Total	76.4	352.2	203.7	28.0	660.3

TABLE 9-3-2 EL OBEID - UM RUABA ROAD
AVERAGE NUMBER OF VEHICLE BY TYPE (ADT)

Traffic by Year		Type of Vehicle: Small Vehicles	Medium Trucks	Large Trucks	Buses	Total
Plan 3						
1983	Normal Traffic	7.7	164.1	20.4	1.4	193.6
	Diverted Traffic	-	-	-	8.5	8.5
	Generated Traffic	18.0	-	-	-	18.0
	Total	25.7	164.1	20.4	9.9	220.1
1992	Normal Traffic	14.1	254.9	84.4	2.5	355.9
	Diverted Traffic	-	-	-	22.5	22.5
	Generated Traffic	33.1	-	-	-	33.1
	Total	47.2	254.9	84.4	25.0	411.5
2002	Normal Traffic	22.9	349.1	203.7	4.0	579.7
	Diverted Traffic	-	-	-	24.0	24.0
	Generated Traffic	53.9	-	-	-	53.9
	Total	76.8	349.1	203.7	28.0	657.6
Plan 4						
1983	Normal Traffic	7.5	165.0	20.4	1.4	194.3
	Diverted Traffic	-	-	-	8.0	8.0
	Generated Traffic	18.0	-	-	-	18.0
	Total	25.5	165.0	20.4	9.4	220.3
1992	Normal Traffic	13.8	256.6	84.4	2.5	357.3
	Diverted Traffic	-	-	-	22.5	22.5
	Generated Traffic	33.1	-	-	-	33.1
	Total	46.9	256.6	84.4	25.0	412.9
2002	Normal Traffic	22.5	351.8	203.7	4.0	582.0
	Diverted Traffic	-	-	-	24.0	24.0
	Generated Traffic	53.9	-	-	-	53.9
	Total	76.4	351.8	203.7	28.0	659.9

TABLE 9-3-3 EL OBEID - UM RUABA ROAD AVERAGE NUMBER OF VEHICLE BY TYPE (ADT)

Traffic by Year		Type of Vehicle: Small Vehicles	Medium Trucks	Large Trucks	Buses	Total
Plan 5						
1983	Normal Traffic	7.7	164.5	20.4	1.4	194.0
	Diverted Traffic	-	-	-	8.0	8.0
	Generated Traffic	18.0	-	-	-	18.0
	Total	25.7	164.5	20.4	9.4	220.0
1992	Normal Traffic	14.1	255.7	84.4	2.5	356.7
	Diverted Traffic	-	-	-	14.7	14.7
	Generated Traffic	33.1	-	-	-	33.1
	Total	47.2	255.7	84.4	17.2	404.5
2002	Normal Traffic	22.9	350.5	203.7	4.0	581.1
	Diverted Traffic	-	-	-	24.0	24.0
	Generated Traffic	53.9	-	-	-	53.9
	Total	76.8	350.5	203.7	28.0	659.0
Plan 6						
1983	Normal Traffic	7.7	163.6	20.4	1.4	193.1
	Diverted Traffic	-	-	-	8.0	8.0
	Generated Traffic	18.0	-	-	-	18.0
	Total	25.7	163.6	20.4	9.4	219.1
1992	Normal Traffic	14.1	254.1	84.4	2.5	355.1
	Diverted Traffic	-	-	-	22.5	22.5
	Generated Traffic	33.1	-	-	-	33.1
	Total	47.2	254.1	84.4	25.0	410.7
2002	Normal Traffic	22.9	347.8	203.7	4.0	578.4
	Diverted Traffic	-	-	-	24.0	24.0
	Generated Traffic	53.9	-	-	-	53.9
	Total	76.8	347.8	203.7	28.0	656.3

TABLE 9-3-4 EL OBIED - UM RUABA ROAD AVERAGE NUMBER OF VEHICLES BY TYPE (ADT) 1)

Traffic by Year		Type of Vehicle: Small Vehicles	Medium Trucks	Large Trucks	Buses	Total
Plan 7						
1983	Normal Traffic	8.9	170.6	20.0	1.4	200.9
	Diverted Traffic	-	-	-	8.0	8.0
	Generated Traffic	18.0	-	-	-	18.0
	Total	26.9	170.6	20.0	9.4	226.9
1992	Normal Traffic	16.3	268.1	82.5	2.5	369.4
	Diverted Traffic	-	-	-	14.7	14.7
	Generated Traffic	33.1	-	-	-	33.1
	Total	49.4	268.1	82.5	17.2	417.2
2002	Normal Traffic	26.5	372.2	199.1	4.0	601.8
	Diverted Traffic	-	-	-	24.0	24.0
	Generated Traffic	53.9	-	-	-	53.9
	Total	80.4	372.2	199.1	28.0	679.7

Note: 1) On the main road

ANNEX X

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ANNEX X-1

TABLE 10-1-1 BYPASSES IN KORDOFAN AREA : A

(LS '000)

Year	Transport Cost			Total	Discounted at 10%	Discounted at 16.6%
	Construction Cost of the Section	Maintenance Cost of the Section	Running Cost of Vehicles			
0) 1978	65			65	65	65
1) 1979						
2) 1980	929			929	768	683
3) 1981						
4) 1982						
5) 1983		2	67	69	43	32
6) 1984		2	72	74	42	29
7) 1985		2	78	80	41	27
8) 1986		2	84	86	40	25
9) 1987		2	90	92	39	23
10) 1988		2	98	100	39	22
11) 1989		2	107	109	38	20
12) 1990		54	117	171	54	27
13) 1991		2	128	130	38	18
14) 1992		2	142	144	38	17
15) 1993		2	149	151	36	15
16) 1994		2	157	159	35	14
17) 1995		2	165	167	33	12
18) 1996	228	2	174	404	73	25
19) 1997		2	184	186	30	10
20) 1998		2	194	196	29	9
21) 1999		2	205	207	28	8
22) 2000		2	217	219	27	7
23) 2001		2	230	232	26	7
24) 2002		2	244	246	25	6
TOTAL					1,587	1,101

TABLE 10-1-2 BYPASSES IN KORDOFAN AREA : B

(LS '000)

Year		Balance of Transport Cost: Construction Cost of the Section	Balance of Transport Cost: Maintenance Cost of the Section	Balance of Transport Cost: Running Cost of Vehicles	Total	Discounted at 10%	Discounted at 16.6%
0)	1978	-					
1)	1979						
2)	1980	-2			-2	-2	-1
3)	1981						
4)	1982						
5)	1983		+1	+2	+3	+2	+1
6)	1984		+1	+2	+3	+2	+1
7)	1985		+1	+3	+4	+2	+1
8)	1986		+1	+3	+4	+2	+1
9)	1987		+1	+3	+4	+2	+1
10)	1988		+1	+3	+4	+2	+1
11)	1989		+1	+4	+5	+2	+1
12)	1990		+2	+4	+6	+2	+1
13)	1991		+1	+4	+5	+1	+1
14)	1992		+1	+5	+6	+2	+1
15)	1993		+1	+5	+6	+1	+1
16)	1994		+1	+5	+6	+1	+1
17)	1995		+1	+5	+6	+1	-
18)	1996	+10	+1	+6	+17	+3	+1
19)	1997			+6	+6	+1	-
20)	1998			+6	+6	+1	-
21)	1999			+7	+7	+1	-
22)	2000			+7	+7	+1	-
23)	2001			+8	+8	+1	-
24)	2002			+8	+8	+1	-
	Total					+29	+12

ANNEX X-2 RAHAD BYPASSES

Studies of bypass alternatives are conducted under the following assumptions.

1. All figures are in terms of economic cost.

2. Detailed engineering work is in 1979 and construction is in 1981.

3. Maintenance cost is estimated by applying the unit cost shown in CHAPTER VII.

4. Vehicle operating cost is estimated by applying the unit cost determined in CHAPTER VI. The number of vehicles is the same as estimated in CHAPTER IX.

5. Running cost of vehicles is estimated under the following assumption. Vehicles having their origin or destination in the Rahad zone enter the centre of the town directly or through the access road. Other through-traffic runs on the main route.

6. Plan E is taken as a base. The figures in the table of Plan D are the balance between E and D, and figures in the table for Plan C are the same, E-C.

7. The total cost discounted at 10% and 16.6% shows that Plan D is the least cost solution followed by Plan C and E. Therefore, Plan D is recommended.

ANNEX X-2

TABLE 10-2-1 BYPASSES IN RAHAD AREA : E

(LS '000)

Year		Transport Cost					
		Construction Cost of the Section	Maintenance Cost of the Section	Running Cost of Vehicles	Total	Discounted at 10%	Discounted at 16.6%
0)	1978						
1)	1979	60			60	54	51
2)	1980						
3)	1981	769			769	578	485
4)	1982						
5)	1983		3	80	83	52	39
6)	1984		3	85	88	50	35
7)	1985		3	92	95	49	32
8)	1986		3	99	102	48	30
9)	1987		3	107	110	47	28
10)	1988		3	117	120	46	26
11)	1989		3	127	130	46	24
12)	1990		62	139	201	64	32
13)	1991		3	153	156	45	21
14)	1992		3	169	172	45	20
15)	1993		3	177	180	43	18
16)	1994		3	187	190	41	16
17)	1995		3	197	200	40	15
18)	1996		3	208	211	38	13
19)	1997		2	219	221	36	12
20)	1998		2	232	234	35	11
21)	1999		2	245	247	33	10
22)	2000		2	259	261	32	9
23)	2001		2	275	277	31	8
24)	2002		2	291	293	30	7
	TOTAL					1,483	942

TABLE 10-2-2 BYPASSES IN RAHAD AREA : D

(LS '000)

Year		Balance of Transport Cost: Construction Cost of the Section	Balance of Transport Cost: Maintenance Cost of the Section	Balance of Transport Cost: Running Cost of Vehicles	Total	Discounted at 10%	Discounted at 16.6%
0)	1978						
1)	1979	-					
2)	1980						
3)	1981	-24			-24	-18	-15
4)	1982						
5)	1983			- 7	- 7	- 4	- 3
6)	1984			- 8	- 8	- 5	- 3
7)	1985			- 9	- 9	- 5	- 3
8)	1986			- 9	- 9	- 4	- 3
9)	1987			-10	-10	- 4	- 3
10)	1988			-11	-11	- 4	- 2
11)	1989			-12	-12	- 4	- 2
12)	1990		- 2	-14	-16	- 5	- 3
13)	1991			-15	-15	- 4	- 2
14)	1992			-17	-17	- 4	- 2
15)	1993			-18	-18	- 4	- 2
16)	1994			-19	-19	- 4	- 2
17)	1995			-20	-20	- 4	- 1
18)	1996			-21	-21	- 4	- 1
19)	1997			-22	-22	- 4	- 1
20)	1998			-24	-24	- 4	- 1
21)	1999			-25	-25	- 3	- 1
22)	2000			-27	-27	- 3	- 1
23)	2001			-28	-28	- 3	- 1
24)	2002			-30	-30	- 3	- 1
	TOTAL					-97	-53

ANNEX X-2

TABLE 10-2-3 BYPASSES IN RAHAD AREA : C

(LS '000)

Year		Balance of Transport Cost: Construction Cost of the Section	Balance of Transport Cost: Maintenance Cost of the Section	Balance of Transport Cost: Running Cost of Vehicles	Total	Discounted at 10%	Discounted at 16.6%
0)	1978	-					
1)	1979						
2)	1980						
3)	1981	+21			+21	16	13
4)	1982						
5)	1983			- 7	- 7	- 4	- 3
6)	1984			- 8	- 8	- 5	- 3
7)	1985			- 9	- 9	- 5	- 3
8)	1986			- 9	- 9	- 4	- 3
9)	1987			-10	-10	- 4	- 3
10)	1988			-11	-11	- 4	- 2
11)	1989			-12	-12	- 4	- 2
12)	1990			-13	-13	- 4	- 2
13)	1991			-15	-15	- 4	- 2
14)	1992			-16	-16	- 4	- 2
15)	1993			-17	-17	- 4	- 2
16)	1994			-18	-18	- 4	- 2
17)	1995			-19	-19	- 4	- 1
18)	1996			-20	-20	- 4	- 1
19)	1997			-21	-21	- 3	- 1
20)	1998			-23	-23	- 3	- 1
21)	1999			-24	-24	- 3	- 1
22)	2000			-26	-26	- 3	- 1
23)	2001			-27	-27	- 3	- 1
24)	2002			-29	-29	- 3	- 1
	TOTAL					-60	-24

ANNEX X-3 STAGED CONSTRUCTION

3.1 Plans

For the comparative study of staged construction, the following plans are proposed, details of which are presented in 8.01.2, CHAPTER VIII.

a) The section taken for the study is between Rahad and Semeih of 20.1 km.

b) Construction plans are as follows.

Type A: DBST for 7 m width at the initial stage. At the second stage in 1996, asphalt concrete overlaying with 5 cm thickness for 7 m width.

Type B: DBST for 6 m width at the initial stage. At the second stage in 1996, AC overlaying with 5 cm thickness for 7 m width.

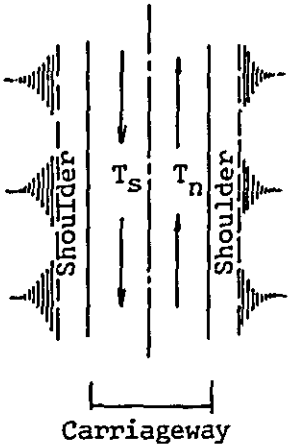
Type C: DBST for 3.5 m width at the initial stage. At the second stage in 1990, AC overlaying with 5 cm thickness for 7 m width.

Type D: At the initial stage, DBST covers for 3.5 m width and base course and subbase course are constructed in compliance with a one-lane road. At the second stage in 1990, AC overlaying with 5 cm thickness for 7 m width. Additional engineering work in base, subbase and earth work should be carried out simultaneously.

Type E: Gravel surfacing for 7 m width at the initial stage. At the second stage in 1993, AC overlaying with 5 cm thickness for 7 m width.

3.2 Encountering Vehicles

Assuming the vehicles running on a section of road are uniformly spaced and run at the same speed, the following relationship is established.



Tn: Hourly traffic in northbound direction (vehicle/hr)

Ts: Hourly traffic in southbound direction (vehicle/hr)

T: Hourly traffic in both directions

V: Speed (km/hr)

H: Hours (hr)

When $V = L/H$ or $L = V.H$ $H = \frac{L}{V}$

a) Traffic Density

Density is defined as the number of vehicles in a particlar length of roadway at a particular moment.

$$Tn/L = Tn/V \times H$$

If it is taken H = 1.0 hour, the density per km is $Tn/L = Tn/V \times H = Tn/V$

b) Encountering

With a density of Tn/V and Ts/V respectively, a vehicle travelling northward encounters vehicles going southward. If the southward vehicles stop on the lane at uniform spacing, the number of encounterings by a vehicle travelling northward is Ts/V, accordingly, for the all vehicles of Tn the number is Ts/V x Tn. In reality, the northward vehicles run at the same speed as Ts and the number of encounterings by Tn doubles, 2 x Ts/V x Tn. Similarly, the number of encounterings by Ts becomes 2 x Tn/V x Ts.

The total number of encounterings for vehicles in both directions is as follows.

$$E = (2 \times Ts/V \times Tn) + (2 \times Tn/V \times Ts)$$

since Ts = Tn = T/2, the above formula becomes

$$E = (2 \times Ts/V \times Ts) + (2 \times Ts/V \times Ts)$$

$$= 4 \cdot Ts^2/V = 4 \cdot \frac{(T/2)^2}{V} = \frac{T2}{V}$$

A representative percentage figure of hourly traffic was derived by actual traffic counting on the paved road between Khartoum and Wad Medani on May 30, 1977. The hourly coefficient in terms of percentage of traffic on the Khartoum - Wad Medani road is shown in Table 10-3-1.

Then, the following formula was established in order to estimate the annual frequency of encountering by a vehicle in both direction per 20.1 km of road

$$\sum_{i=1}^{24} Ii^2 \times 20.1(km) \times 365 \times \frac{(ADT)^2}{V} = 0.057822 \times 20.1 \times 365 \times \frac{(ADT)^2}{V}$$

$$= 7.070185 \times (ADT)^2$$

The number of encounters in both directions per 20.1 km by all vehicles for the 20-year project life is calculated in Table 10-3-2.

ANNEX X-3

TABLE 10-3-1 HOURLY COEFFICIENT OF TRAFFIC

Time	Number of Vehicles in both Directions	Hourly Coefficient (%)
5 - 6	126	4.7
6 - 7	202	7.5
7 - 8	242	9.0
8 - 9	236	8.8
9 - 10	110	4.1
10 - 11	159	5.9
11 - 12	130	4.9
12 - 13	153	5.7
13 - 14	148	5.5
14 - 15	135	5.0
15 - 16	138	5.2
16 - 17	179	6.7
17 - 18	154	5.8
18 - 19	146	5.5
19 - 20	111	4.1
20 - 21	103	3.9
21 - 22	63	2.4
22 - 23	35	1.3
23 - 24	23	0.9
24 - 1	20	0.7
1 - 2	14	0.5
2 - 3	12	0.5
3 - 4	19	0.7
4 - 5	20	0.7
Total	2,678	100.0

TABLE 10-3-2 NUMBER OF ENCOUNTERS

Year	ADT [1]	Number of Encounters by All Vehicles in Both Directions	Number of Encounters
1983	221.9	348,133	174,067
1984	237.4	398,467	199,234
1985	254.0	456,140	228,070
1986	271.8	522,312	261,156
1987	290.8	597,888	298,944
1988	311.2	684,715	342,358
1989	333.0	784,006	392,003
1990	356.3	897,558	448,779
1991	381.2	1,027,393	513,697
1992	407.9	1,176,354	588,177
1993	428.3	1,296,961	648,481
1994	449.7	1,429,804	714,902
1995	472.2	1,576,459	788,230
1996	495.8	1,737,976	868,988
1997	520.6	1,916,192	958,096
1998	546.6	2,112,370	1,056,185
1999	574.0	2,329,456	1,164,728
2000	602.7	2,568,226	1,284,113
2001	632.8	2,831,155	1,415,578
2002	664.4	3,120,973	1,560,487

Note: 1) From FIG. IX-1-2. The figures include the diverted and generated traffic.

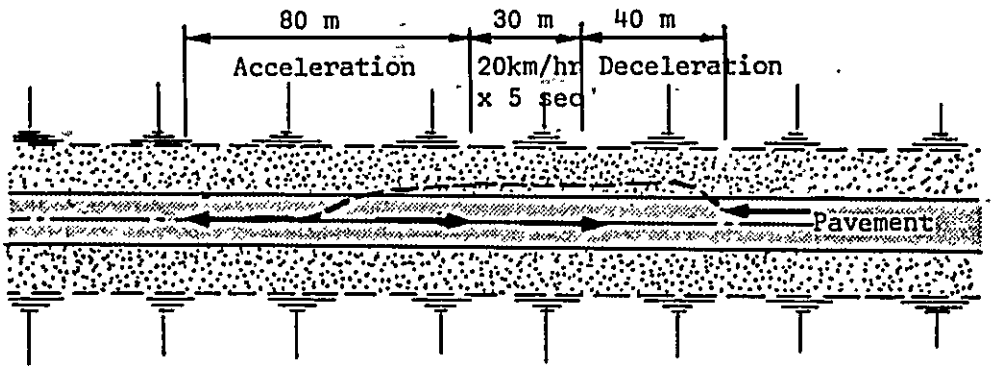
3.3 Additional Cost in Speed Change

The vehicle operating cost in acceleration and deceleration was estimated by applying a study conducted by Lional Odier. In his study, the additional cost of a speed change is converted to an additional running distance as shown in FIG. 10-3-1. Speed changes and their costs are calculated in Table 10-3-3.

There is no speed change for vehicles on a road of Type A. Vehicles on a Type B road reduce speed at encountering because the carriageway width is narrower than that of Type A. The speed change is assumed to be from the normal speed of 60 km/hr to 40 km/hr and return to 60 km/hr.

It is assumed that vehicles on a one-lane road of Types C and D will reduce speed from 60 km/hr to 20 km/hr and return to 60 km/hr. Also, additional increases in vehicle operating cost, beside speed changes, should be considered. That is, vehicles in one direction must leave the paved lane and run on the gravel surfaced lane when encountering approaching vehicles. The encountering is shown as follows, and the excess running cost for a distance of 70 m on a gravel surfaced lane is estimated by applying the running cost figures in Table VI-14, CHAPTER VI.

Normal Running Speed		Deceleration	Acceleration
	Speed change	60 → 20 km/hr	20 → 60 km/hr
60 km/hr	α : m/sec^2	3.0	1.5
	Length	40 m	30 m

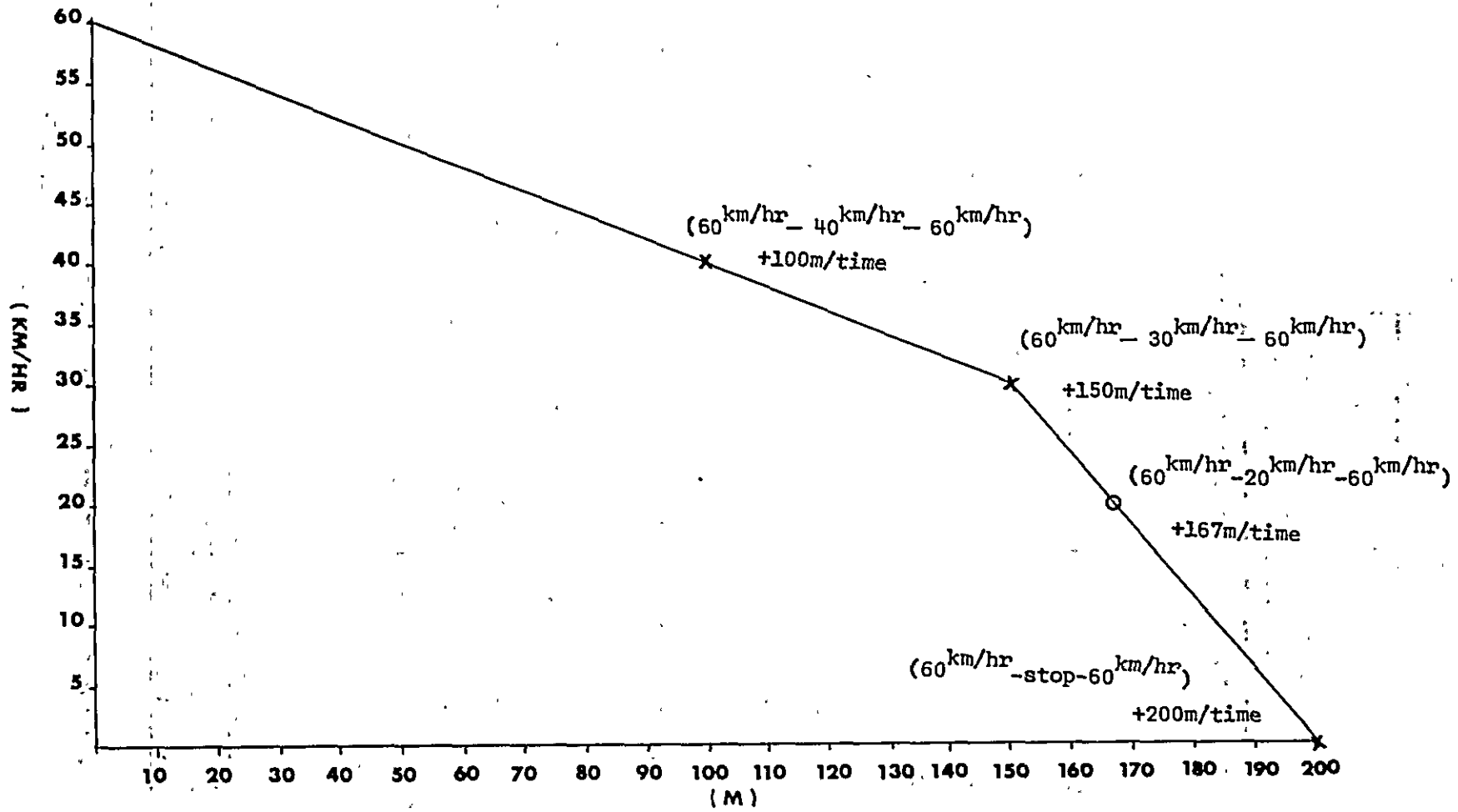


This estimate is applicable for one-lane roads of Types C and D. In the case of Type D a graveled lane is not provided; instead, shoulders of 2 m width will be constructed on each side in the first stage. All the encountering vehicles will run on both shoulders. The additional vehicle costs will be greater than for those in Type C. They are shown in Tables 10-3-4 and 10-3-5, where a medium sized truck is the representative vehicle.

Vehicles on gravel surfaced roads such as Type E are considered to have greater running costs than those on bituminous surfaced roads. Additional vehicle running costs on gravel roads over bituminous surfaced ones are estimated as below by applying the unit costs of Table VI-12 to 16, CHAPTER VI. Table 10-3-6 shows the excess costs for the years up to 1993.

Medium Sized Truck			
Running Cost per km on Gravel (1)	Running Cost per km on Paved (2)	Balance (1)-(2)	Excess Cost per Encounter
93.99 mm/km	71.92 mm/km	22.07 mm/km	22.07 mm/km x 0.07 km = 0.0015449

FIG. 10-3-1 EQUIVALENT ADDITIONAL RUNNING DISTANCE REPRESENTED BY THE COST OF SLOWING DOWN AND STOPPING



Source: Lionel ODIER, THE ECONOMIC BENEFIT OF ROAD CONSTRUCTION AND IMPROVEMENTS (Paris: Publications ESTOUP, 1963), Table 10.

ANNEX X-3

TABLE 10-3-3 EXCESS COST DUE TO ENCOUNTERS

(LS in Economic Cost)

	Number of Encounters per year	Plan B 60 km/hr — 40 — 60 (7.19 mm/Time)	Plan C & D 60 — 20 — 60 (12.01 mm/Time)	60 — stop — 60 (14.38 mm/Time)
1983	348,133	2,503	4,181	5,006
1984	398,467	2,865	4,786	5,730
1985	456,140	3,280	5,478	6,559
1986	522,312	3,755	6,273	7,511
1987	597,888	4,399	7,181	8,598
1988	684,715	4,923	8,223	9,846
1989	784,006	5,637	9,416	11,274
1990	897,558	6,453	10,780	12,907
1991	1,027,393	7,387	12,339	14,774
1992	1,176,354	8,458	14,128	16,916
1993	1,296,961	9,325	15,577	18,650
1994	1,429,804	10,280	17,172	20,561
1995	1,576,459	11,335	18,933	22,669
1996	1,737,976	12,496	20,873	24,992
1997	1,916,192	13,777	23,013	27,555
1998	2,112,370	15,188	25,370	30,376
1999	2,329,456	16,749	27,977	33,498
2000	2,568,226	18,466	30,844	36,931
2001	2,831,155	20,356	34,002	40,712
2002	3,120,973	22,440	37,483	44,880

ANNEX X-3

TABLE 10-3-4 EXCESS RUNNING COST FOR PLAN C

Year	Excess Cost per Encounter	Number of Encounters per Year	Excess Cost in LS
1983	0.0015449	174,067	369
1984	"	199,234	308
1985	"	228,070	352
1986	"	261,156	403
1987	"	298,944	462
1988	"	342,358	529
1989	"	392,003	606
1990	"	448,779	693

ANNEX X-3

TABLE 10-3-5 EXCESS RUNNING COST FOR PLAN D

Year	Excess Cost per Encounter	Number of Encounters per Year	Excess Cost in LS
1983	0.0015449	348,133	538
1984	"	398,467	616
1985	"	456,140	705
1986	"	522,312	807
1987	"	597,888	924
1988	"	684,715	1,058
1989	"	784,006	1,211
1990	"	897,558	1,387

TABLE 10-3-6 EXCESS RUNNING COST FOR PLAN E

Year	ADT	365 days x 20.1 km x 0.02207 LS (161.91655)	Excess Cost in LS
1983	221.9	161.91655	35,929
1984	237.4	"	38,439
1985	254.0	"	41,127
1986	271.8	"	44,009
1987	290.8	"	47,085
1978	311.2	"	50,388
1989	333.0	"	53,918
1990	356.3	"	57,691
1991	381,2	"	61,723
1992	407.9	"	66,046
1993	428.3	"	69,349

3.4 Cost Estimate

For the construction of the section which is 20.1 km in length, the following programme is proposed. Detailed engineering will be conducted in 1979. Construction will begin in 1981, and overlaying either in 1990 or 1996 whenever the accumulated number of equivalent axles reaches 700,000 repetitions. For a gravel surfaced road, the accumulated number is 500,000, AC will be overlaid. Yearly maintenance cost is estimated also. These assumptions together with the process of cost estimation are the same as for the cost estimation of all the alternative plans as covered in 7.03, CHAPTER VII. Tables 10-3-7 and 10-3-8 show the estimated economic costs of construction and maintenance for different pavement designs.

TABLE 10-3-7 CONSTRUCTION COST BY TYPE OF PAVEMENT

Rahad-Semeih
Distance 20.1 km

(LS'000 in 1977)

Item		Type A	B	C	D	E
1st Stage Construction ('81)	Earthwork	658	655	647	611	658
	Pavement	613	590	533	477	551
	Structures	68	68	68	68	68
	Sub Total	1,339	1,313	1,248	1,156	1,277
	Add. Cost	374	367	348	323	357
	TOTAL	1,713	1,680	1,596	1,379	1,634
	(Cost per km)	(85.2)	(83.6)	(79.4)	(68.6)	(81.3)
2nd Stage Construction ('96)	Earthwork	-	-	-	75	-
	Pavement	324	324	324	393	324
	Sub Total	324	324	324	468	324
	Add. Cost	90	90	90	131	90
	TOTAL	414	414	414 1)	599 1)	414 2)
	(Cost per km)	(20.6)	(20.6)	(20.6)	(29.8)	(20.6)

Notes: 1) Overlaying is scheduled in 1990.

2) Overlaying is scheduled in 1993.

TABLE 10-3-8 MAINTENANCE AND REPAIR COST BY TYPE OF PAVEMENT

(LS in 1977 Price)

	Year	Type A	Type B	Type C	Type D	Type E
1	1983	3,400	3,900	4,800	3,500	7,700
2	1984	3,400	3,900	4,800	3,500	7,700
3	1985	3,400	3,900	7,000	5,000	7,700
4	1986	3,400	3,900	7,000	5,000	7,700
5	1987	3,400	3,900	7,000	5,000	7,700
6	1988	3,400	3,900	43,300	41,300	154,500
7	1989	3,400	3,900	7,000	5,000	7,700
8	1990	76,000	66,200	7,000	5,000	7,700
9	1991	3,400	3,900	2,800	2,800	7,700
10	1992	3,400	3,900	2,800	2,800	7,700
11	1993	3,400	3,900	2,800	2,800	7,700
12	1994	3,400	3,900	2,800	2,800	2,800
13	1995	3,400	3,900	2,800	2,800	2,800
14	1996	3,400	3,900	2,800	2,800	2,800
15	1997	2,800	2,800	2,800	2,800	2,800
16	1998	2,800	2,800	2,800	2,800	2,800
17	1999	2,800	2,800	2,800	2,800	2,800
18	2000	2,800	2,800	2,800	2,800	2,800
19	2001	2,800	2,800	2,800	2,800	2,800
20	2002	2,800	2,800	2,800	2,800	2,800
	TOTAL	137,000	133,700	121,500	106,900	256,700

3.5 BC Analysis of Stage Construction

For the comparative study of the five plans of alternative stage construction, Type A is taken as a base; that is, the streams of the road costs and vehicle running cost for the project's life period are developed first. Then, the estimated costs of other types are compared to find the balances between each type and Type A. The yearly value of the balance is discounted at the compound rate of 10% and 16.6%, respectively. The results are shown in Table 10-3-9 ~13. Type E, a gravel surfaced road, is rejected because of high cost. Type D seems to be the lowest cost plan, in terms of net present worth, among the five alternatives.

However, it is recognized that a one-lane paved road offers greater potential for head-on traffic accidents than a two-lane road. The economic loss from vehicle accidents could not be estimated because of a scarcity of reliable data. Since the balance of present worth between Type A and C or Type A and D is relatively small and the possibility of accidents is large, it is determined not to recommend either of the two types of one-lane paved road (Types C and D) as a stage construction plan for the project road.

Surfacings of Type A and B have resulted in the same value in total transport cost when discounted by 10%. Type B is more economical when discounted at the rate of 16.6%. Considering the facts that the initial investment is smaller in the case of Type B and that there will no increment in accident probability between the paved road of 7 m width and one of 6 m width, with an ADT of about 200 in the opening year and about 500 for the year of second stage construction (overlaying AC to 7 m width), Type B is recommended as the best construction plan for the project road.

TABLE 10-3-9 TYPE A: TRANSPORT COST ON 7M WIDTH PAVED ROAD

Year	Transport Cost			Total	Discounted at 10%	Discounted at 16.6%
	Initial Cost	Maintenance Cost	Running Cost			
0) 1978						
1) 1979	120			120	109	103
2) 1980						
3) 1981	1,593			1,593	1,197	1,005
4) 1982						
5) 1983		3	117	120	75	56
6) 1984		3	125	128	72	51
7) 1985		3	134	137	70	47
8) 1986		3	143	146	68	43
9) 1987		3	153	156	66	39
10) 1988		3	164	167	64	36
11) 1989		3	176	179	63	33
12) 1990		76	188	264	84	42
13) 1991		3	201	204	59	28
14) 1992		3	215	218	57	25
15) 1993		3	226	229	55	23
16) 1994		3	237	240	52	21
17) 1995		3	249	252	50	19
18) 1996	414	3	262	679	122	43
19) 1997		3	275	278	45	15
20) 1998		3	288	291	43	13
21) 1999		3	303	306	41	12
22) 2000		3	318	321	39	11
23) 2001		3	334	337	38	10
24) 2002		3	351	354	36	9
Total					2,505	1,684

TABLE 10-3-10 TYPE B: BALANCE OF TRANSPORT COST

Year	Initial Cost	Maintenance Cost	Cost by Encounter	Cost on Gravel	Total	Discounted at 10%	Discounted at 16.6%
0) 1978							
1) 1979							
2) 1980							
3) 1981	-33				-33	-25	-21
4) 1982							
5) 1983		+1	+3		+4	+2	+2
6) 1984		+1	+3		+4	+2	+2
7) 1985		+1	+3		+4	+2	+1
8) 1986		+1	+4		+4	+2	+1
9) 1987		+1	+4		+4	+2	+1
10) 1988		+1	+5		+6	+2	+1
11) 1989		+1	+6		+7	+2	+1
12) 1990		-10	+6		-4	-1	-1
13) 1991		+1	+7		+8	+2	+1
14) 1992		+1	+8		+9	+2	+1
15) 1993		+1	+9		+10	+2	+1
16) 1994		+1	+10		+11	+2	+1
17) 1995		+1	+11		+12	+2	+1
18) 1996		+1	+12		+13	+2	+1
19) 1997							
20) 1998							
21) 1999							
22) 2000							
23) 2001							
24) 2002							
Total						0	-7

TABLE 10-3-11 TYPE C: BALANCE OF TRANSPORT COST

Year	Initial Cost	Maintenance Cost	Cost by Encounter	Cost on Gravel	Total	Discounted at 10%	Discounted at 16.6%
0) 1978							
1) 1979							
2) 1980							
3) 1981	-117				-117	-88	-74
4) 1982							
5) 1983		+2	+4		+6	+4	+3
6) 1984		+2	+5		+7	+4	+3
7) 1985		+4	+5		+9	+5	+3
8) 1986		+4	+6		+10	+5	+3
9) 1987		+4	+7		+11	+5	+3
10) 1988		+40	+8	+1	+49	+19	+11
11) 1989		+4	+9	+1	+14	+5	+3
12) 1990	+414	-69	+11	+1	+357	+114	+57
13) 1991							
14) 1992							
15) 1993							
16) 1994							
17) 1995							
18) 1996	-414				-414	-74	-26
19) 1997							
20) 1998							
21) 1999							
22) 2000							
23) 2001							
24) 2002							
Total						-1	-14

TABLE 10-3-12 TYPE D: BALANCE OF TRANSPORT COST

Year	Initial Cost	Maintenance Cost	Cost by Encounter	Cost on Gravel	Total	Discounted at 10%	Discounted at 16.6%
0) 1978							
1) 1979							
2) 1980							
3) 1981	-334				-334	-251	-211
4) 1982							
5) 1983		+1	+5	+1	+7	+4	+3
6) 1984		+1	+6	+1	+8	+5	+3
7) 1985		+2	+7	+1	+10	+5	+3
8) 1986		+2	+8	+1	+11	+5	+3
9) 1987		+2	+9	+1	+12	+5	+3
10) 1988		+38	+10	+1	+49	+19	+11
11) 1989		+2	+11	+1	+14	+5	+3
12) 1990	+599	-71	+13	+1	+542	+173	+86
13) 1991							
14) 1992							
15) 1993							
16) 1994							
17) 1995							
18) 1996	-414				-415	-75	-26
19) 1997							
20) 1998							
21) 1999							
22) 2000							
23) 2001							
24) 2002							
Total						-104	-122

TABLE 10-3-13 TYPE E: BALANCE OF TRANSPORT COST

Year	Initial Cost	Maintenance Cost	Cost by Encounter	Cost on Gravel	Total	Discounted at 10%	Discounted at 16.6%
0) 1978							
1) 1979							
2) 1980							
3) 1981	-79				-79	-59	-50
4) 1982							
5) 1983		+5		+36	+41	+25	+12
6) 1984		+5		+38	+43	+24	+17
7) 1985		+5		+41	+46	+24	+16
8) 1986		+5		+44	+49	+23	+14
9) 1987		+5		+47	+52	+22	+13
10) 1988		+152		+50	+202	+78	+43
11) 1989		+5		+53	+58	+20	+11
12) 1990		-68		+58	-10	-3	-2
13) 1991				+62	+62	+18	+8
14) 1992				+66	+66	+17	+8
15) 1993	+414			+69	+483	+116	+48
16) 1994							
17) 1995							
18) 1996	-414				-414	-74	-26
19) 1997							
20) 1998							
21) 1999							
22) 2000							
23) 2001							
24) 2002							
Total						+231	+112

TABLE 10-4-1 TRANSPORT COST: PAVEMENT DESIGN BY AASHTO

Year	Initial Cost	Maintenance Cost	Running Cost	Cost by Encounter	Total	Discounted at 10%	Discounted at 16.6%
0) 1978							
1) 1979	120				120	109	103
2) 1980							
3) 1981	1,560				1,560	1,172	984
4) 1982							
5) 1983		4	117	3	124	77	58
6) 1984		4	125	3	132	75	53
7) 1985		4	134	3	141	72	48
8) 1986		4	143	4	151	70	44
9) 1987		4	153	4	161	68	40
10) 1988		4	164	5	173	67	37
11) 1989		4	176	6	186	65	34
12) 1990		66	188	6	260	83	41
13) 1991		4	201	7	212	61	29
14) 1992		4	215	8	227	60	26
15) 1993		4	226	9	239	57	24
16) 1994		4	237	10	251	55	22
17) 1995		4	249	11	264	52	19
18) 1996	414	4	262	12	692	124	44
19) 1997		3	275		278	45	15
20) 1998		3	288		291	43	13
21) 1999		3	303		303	41	12
22) 2000		3	318		321	39	11
23) 2001		3	334		337	38	10
24) 2002		3	351		354	36	9
Total						2,509	1,676

TABLE 10-4-2 BALANCE OF TRANSPORT COST:
PAVEMENT DESIGN BY LOW COST ROADS

Year	Initial Cost	Maintenance Cost	Running Cost	Cost by Encounter	Total	Discounted at 10%	Discounted at 16.6%
0) 1978							
1) 1979							
2) 1980							
3) 1981	-109				-109	-82	-69
4) 1982							
5) 1983							
6) 1984							
7) 1985							
8) 1986							
9) 1987							
10) 1988							
11) 1989							
12) 1990							
13) 1991							
14) 1992							
15) 1993	+414				+414	+99	+41
16) 1994		-1			-1		
17) 1995		-1			-1		
18) 1996	-414	-1			-415	-75	-26
19) 1997							
20) 1998							
21) 1999							
22) 2000							
23) 2001							
24) 2002							
Total						-58	-54

ANNEX X-5 Bridges

Studies concerning types of bridges are conducted under the following assumptions.

1. All figures are in terms of economic cost.

2. All bridges are to be constructed simultaneously in 1980.

3. Maintenance cost is estimated as shown in Table 10-5-1 and 10-5-2, Annex X-5.

4. Vehicle operating cost per km and number of vehicles are the same as in CHAPTER VI and IX, respectively.

5. The unit cost of vehicle stoppages in the case of a submergible bridge is the same as in Annex X-3.

6. Normal bridges are taken as a base and the construction cost, maintenance cost and vehicle running cost are estimated as in Table 10-5-1. The balance of the cost of each of the above items for submergible bridges is presented in Table 10-5-2.

7. The result shows, if discounted by 10% p.a., that a submergible bridge is more expensive than a normal bridge. If discounted by 16.6%, a normal bridge becomes more expensive than a submergible bridge.

8. As stated in 10.02.1, CHAPTER X, the construction of normal bridges is recommended.

TABLE 10-5-1 TRANSPORT COST: NORMAL BRIDGES

(LS)

Year	Construction Cost	Maintenance Cost	Waiting Cost	Cost by Stop	Total	Discounted at 10%	Discounted at 16.6%
0) 1978	20,000						
1) 1979							
2) 1980	287,332				287,332	237,464	211,343
3) 1981							
4) 1982							
5) 1983		157			157	97	73
6) 1984		157			157	89	62
7) 1985		157			157	81	54
8) 1986		157			157	73	46
9) 1987		157			157	67	39
10) 1988		157			157	61	34
11) 1989		157			157	55	29
12) 1990		2,582			2,582	823	409
13) 1991		157			157	45	21
14) 1992		2,782			2,782	733	324
15) 1993		157			157	38	16
16) 1994		157			157	34	13
17) 1995		157			157	31	12
18) 1996	11,298	157			11,455	2,060	722
19) 1997		115			115	19	6
20) 1998		115			115	17	5
21) 1999		115			115	16	5
22) 2000		115			115	14	4
23) 2001		115			115	13	3
24) 2002		115			115	12	3
Total						241,842	213,223

TABLE 10-5-2 BALANCE OF TRANSPORT COST: SUBMERGIBLE BRIDGES

(LS)

Year	Construction Cost	Maintenance Cost	Waiting Cost	Cost by Stop	Total	Discounted at 10%	Discounted at 16.6%
0) 1978	-						
1) 1979							
2) 1980	-47,852				-47,852	-39,547	-35,197
3) 1981							
4) 1982							
5) 1983		+280	+4,668	+29	+4,977	3,090	2,309
6) 1984		+280	+4,994	+31	+5,305	2,995	2,111
7) 1985		+280	+5,344	+33	+5,657	2,903	1,931
8) 1986		+280	+5,718	+35	+6,033	2,814	1,766
9) 1987		+280	+6,118	+38	+6,436	2,729	1,616
10) 1988		+280	+6,547	+40	+6,867	2,648	1,478
11) 1989		+280	+6,942	+43	+7,265	2,546	1,341
12) 1990		-2,145	+7,496	+46	+5,397	1,720	855
13) 1991		+280	+8,019	+49	+8,348	2,418	1,134
14) 1992		+24,781	+8,581	+53	+33,415	8,799	3,892
15) 1993		+280	+9,010	+55	+9,345	2,237	933
16) 1994		+280	+9,461	+58	+9,799	2,133	839
17) 1995		+280	+9,934	+61	+10,275	2,033	755
18) 1996		+280	+10,430	+64	+10,774	1,938	679
19) 1997		+322	+10,952	+67	+11,341	1,854	613
20) 1998		+322	+11,499	+71	+11,892	1,768	551
21) 1999		+322	+12,076	+74	+12,472	1,685	496
22) 2000		+322	+12,679	+78	+13,079	1,607	446
23) 2001		+322	+13,313	+82	+13,717	1,532	401
24) 2002		+322	+13,977	+86	+14,385	1,460	361
Total						11,362	-10,690

TABLE 10-6-1 BENEFIT COST STREAMS: SECTION I (1+2)

DISCOUNT RATE = 0.100 B-C = 1392 B/C = 1.5602

ECON. RETURN = 0.163

			C1	C2	CT	CTD	AGGR.	B1	B2	B3	BT	BTD	AGGR.
1978	0		129		129	129	129						
1979	1		93		93	80	209						
1980	2		2351		2351	1740	1949						
1981	3	1		9	9	6	1955	308			308	196	196
1982	4	2		9	9	5	1960	330			330	181	377
1983	5	3		9	9	4	1964	354			354	167	544
1984	6	4		9	9	4	1968	380			380	154	698
1985	7	5		9	9	3	1971	411			411	143	841
1986	8	6		9	9	3	1974	443			443	133	974
1987	9	7		9	9	2	1976	480			480	124	1098
1988	10	8		151	151	33	2009	524			524	116	1214
1989	11	9		9	9	2	2011	573			573	109	1323
1990	12	10		9	9	1	2012	630			630	103	1426
1991	13	11	741	9	750	106	2118	694			694	98	1524
1992	14	12		6	6	1	2119	770			770	93	1617
1993	15	13		6	6	1	2120	812			812	85	1702
1994	16	14		6	6	1	2121	857			857	77	1779
1995	17	15		6	6		2121	904			904	70	1849
1996	18	16		6	6		2121	956			956	64	1913
1997	19	17		6	6		2121	1010			1010	58	1971
1998	20	18		6	6		2121	1069			1069	53	2024
1999	21	19		6	6		2121	1133			1133	48	2072
2000	22	20		6	6		2121	1200			1200	44	2116

Note: Traffic growth rates of 7% p.a. up to 1992 and 5% thereafter up to 2002.

DISCOUNT RATE = 0.100 B-C = 645 B/C = 1.2596

ECON. RETURN = 0.133

			C1	C2	CT	CTD	AGGR.	B1	B2	B3	BT	BTD	AGGR.
1978	0		129		129	129	129						
1979	1		93		93	87	211						
1980	2		2351		2351	1832	2043						
1981	3	1		9	9	6	2049	286			286	197	197
1982	4	2		9	9	5	2054	299			299	182	379
1983	5	3		9	9	5	2059	315			315	169	548
1984	6	4		9	9	4	2063	333			333	158	706
1985	7	5		9	9	4	2067	352			352	147	853
1986	8	6		9	9	3	2070	374			374	138	991
1987	9	7		9	9	3	2073	397			397	129	1120
1988	10	8		151	151	49	2116	425			425	122	1242
1989	11	9		9	9	2	2118	456			456	116	1358
1990	12	10		9	9	2	2120	491			491	110	1468
1991	13	11	741	9	750	148	2268	530			530	105	1573
1992	14	12		6	6	1	2269	578			578	101	1674
1993	15	13		6	6	1	2270	608			608	94	1768
1994	16	14		6	6	1	2271	642			642	87	1855
1995	17	15		6	6	1	2272	678			678	81	1936
1996	18	16		6	6	1	2273	716			716	76	2012
1997	19	17		6	6	1	2274	758			758	71	2083
1998	20	18		6	6		2274	801			801	66	2149
1999	21	19		6	6		2274	848			848	62	2211
2000	22	20		6	6		2274	901			901	58	2269

Note: Traffic growth rate of 5% p.a. from 1977 up to the end of the project life.

TABLE 10-6-2 BENEFIT COST STREAMS: SECTION II (3+4)

DISCOUNT RATE = 0.100 B-C = 2057 B/C = 1.9204

ECON. RETURN = 0.194

			C1	C2	CT	CTD	AGGR.	B1	B2	B3	BT	BTD	AGGR.
1978	0		117		117	117	117						
1979	1		94		94	79	196						
1980	2						196						
1981	3		2345		2345	1377	1573						
1982	4	1		8	8	4	1577	374			374	184	184
1983	5	2		8	8	3	1580	402			402	166	350
1984	6	3		8	8	3	1583	431			431	149	499
1985	7	4		8	8	2	1585	464			464	134	633
1986	8	5		8	8	2	1587	503			503	122	755
1987	9	6		8	8	2	1589	546			546	111	866
1988	10	7		8	8	1	1590	595			595	101	967
1989	11	8		138	138	20	1610	648			648	92	1059
1990	12	9		8	8	1	1611	713			713	85	1144
1991	13	10		8	8	1	1612	788			788	78	1222
1992	14	11	677	8	685	57	1669	872			872	73	1295
1993	15	12		6	6		1669	920			920	64	1359
1994	16	13		6	6		1669	970			970	57	1416
1995	17	14		6	6		1669	1024			1024	50	1466
1996	18	15		6	6		1669	1082			1082	44	1510
1997	19	16		6	6		1669	1145			1145	39	1549
1998	20	17		6	6		1669	1211			1211	35	1584
1999	21	18		6	6		1669	1284			1284	31	1615
2000	22	19		6	6		1669	1360			1360	27	1642
2001	23	20		6	6		1669	1443			1443	24	1666

Note: Traffic growth rates of 7% p.a. up to 1992 and 5% thereafter up to 2002.

DISCOUNT RATE = 0.100 B-C = 1285 B/C = 1.5302

ECON. RETURN = 0.161

			C1	C2	CT	CTD	AGGR.	B1	B2	B3	BT	BTD	AGGR.
1978	0		117		117	117	117						
1979	1		94		94	81	198						
1980	2						196						
1981	3		2345		2345	1497	1695						
1982	4	1		8	8	4	1699	340			340	187	187
1983	5	2		8	8	4	1703	358			358	170	357
1984	6	3		8	8	3	1706	377			377	154	511
1985	7	4		8	8	3	1709	398			398	140	651
1986	8	5		6	8	2	1711	423			423	128	779
1987	9	6		8	8	2	1713	450			450	117	896
1988	10	7		6	6	2	1715	481			481	108	1004
1989	11	8		138	138	27	1742	517			517	100	1104
1990	12	9		8	8	1	1743	557			557	93	1197
1991	13	10		8	8	1	1744	602			602	86	1283
1992	14	11	677	8	685	84	1828	655			655	81	1364
1993	15	12		6	6	1	1829	690			690	73	1437
1994	16	13		6	6	1	1830	727			727	66	1503
1995	17	14		6	6		1830	769			769	61	1564
1996	18	15		6	6		1830	812			812	55	1619
1997	19	16		6	6		1830	857			857	50	1669
1998	20	17		6	6		1830	908			908	46	1715
1999	21	18		6	6		1830	963			963	42	1757
2000	22	19		6	6		1830	1020			1020	38	1795
2001	23	20		6	6		1830	1081			1081	35	1830

Note: Traffic growth rate of 5% p.a. from 1977 up to the end of the project life.

TABLE 10-6-3 BENEFIT COST STREAMS: SECTION III (5+6)

DISCOUNT RATE = 0.100 B-C = 1963 B/C = 1.6823

ECON. RETURN = 0.171

			C1	C2	CT	CTD	AGGR.	B1	B2	B3	BT	BTD	AGGR.
1978	0		134		134	134	134						
1979	1		137		137	117	251						
1980	2						251						
1981	3						251						
1982	4		3411		3411	1812	2063						
1983	5	1		10	10	5	2068	478			478	217	217
1984	6	2		10	10	4	2072	512			512	198	415
1985	7	3		10	10	3	2075	550			550	182	597
1986	8	4		10	10	3	2078	593			593	167	764
1987	9	5		10	10	2	2080	641			641	155	919
1988	10	6		10	10	2	2082	695			695	143	1062
1989	11	7		10	10	2	2084	757			757	133	1195
1990	12	8		162	162	24	2108	827			827	124	1319
1991	13	9		10	10	1	2109	908			908	116	1435
1992	14	10		10	10	1	2110	1001			1001	109	1544
1993	15	11	773	10	783	75	2183	1053			1053	98	1642
1994	16	12		6	6		2183	1107			1107	88	1730
1995	17	13		6	6		2183	1166			1166	79	1809
1996	18	14		6	6		2183	1229			1229	71	1880
1997	19	15		6	6		2183	1297			1297	64	1944
1998	20	16		6	6		2183	1369			1369	58	2002
1999	21	17		6	6		2183	1447			1447	52	2054
2000	22	18		6	6		2183	1530			1530	47	2101
2001	23	19		6	6		2183	1620			1620	43	2144
2002	24	20		6	6		2183	1715			1715	39	2183

Note: Traffic growth rates of 7% p.a. up to 1992 and 5% thereafter up to 2002.

DISCOUNT RATE = 0.100 B-C = 949 B/C = 1.3299

ECON. RETURN = 0.139

			C1	C2	CT	CTD	AGGR.	B1	B2	B3	BT	BTD	AGGR.
1978	0		134		134	134	134						
1979	1		137		137	120	254						
1980	2						254						
1981	3						254						
1982	4		3411		3411	2026	2280						
1983	5	1		10	10	5	2285	426			426	222	222
1984	6	2		10	10	5	2290	449			449	206	428
1985	7	3		10	10	4	2294	472			472	190	618
1986	8	4		10	10	4	2298	500			500	176	794
1987	9	5		10	10	3	2301	529			529	164	958
1988	10	6		10	10	3	2304	564			564	153	1111
1989	11	7		10	10	2	2306	601			601	144	1255
1990	12	8		162	162	34	2340	646			646	135	1390
1991	13	9		10	10	2	2342	695			695	128	1518
1992	14	10		10	10	2	2344	750			750	121	1639
1993	15	11	773	10	783	111	2455	790			790	112	1751
1994	16	12		6	6	1	2456	833			830	103	1854
1995	17	13		6	6	1	2457	876			876	96	1950
1996	18	14		6	6	1	2458	922			922	89	2039
1997	19	15		6	6	1	2459	972			972	82	2121
1998	20	16		6	6		2459	1026			1026	76	2197
1999	21	17		6	6		2459	1085			1085	70	2267
2000	22	18		6	6		2459	1147			1147	65	2332
2001	23	19		6	6		2459	1214			1214	61	2393
2002	24	20		6	6		2459	1286			1286	57	2450

Note: Traffic growth rate of 5% p.a. from 1977 up to the end of the project life.

TABLE 10-7 SENSITIVITY ANALYSIS

	Traffic Growth Rate : 7%-5%			Traffic Growth Rate : 5%		
	Economic Rate of Return (%)	B/C Ratio 1)	Present Worth 1) (LS '000)	Economic Rate of Return (%)	B/C Ratio 1)	Present Worth 1) (LS '000)
The Conclusion	19	1.93	7,058	16	1.55	4,186
If diverted and generated benefits are excluded	17	1.77	5,844	14	1.41	3,104
If the project cost is increased by 20%	16	1.61	5,542	13	1.29	2,670
If the project cost is increased by 30%	15	1.48	4,778	12	1.19	1,906
If the project cost is increased by 50%	13	1.29	3,257	10	1.03	385

Note: 1) Discounted at a rate of 10% p.a.