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TECHNICAL/ECONOMIC ANALYSIS
FEEDER ROAD COMPONENT
KORDOFAN RAINFED AGRICULTURE
PROJECT PAPER

6500454

Prepared for

USAID

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by

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November 19, 1984

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Dear Mr. Pascual:

Wilbur Smith and Associates is pleased to forward its technical and economic analysis of the Feeder Road Component of the Kordofan Rainfed Agriculture Project Paper, prepared under the Terms of IQC OTR-1406-I-OD-2253-00.

The report is presented in three parts: Part I - Technical Analysis, Part II - Economic Analysis, and Part III - Attachments.

We enjoyed the opportunity to contribute to this interesting project and trust these documents meet with your approval.

Very truly yours,

WILBUR SMITH AND ASSOCIATES

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Vice President

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PART I
TECHNICAL ANALYSIS

A. Technical Analysis

1. General Road Conditions

Except for the paved road extending north 186 km from Kadugli to Dubiebat via Dilling, there are presently no paved roads in the Kordofan Region. Two additional roads, however, are scheduled for improvement to a paved road standard. (See Figure A-1). The 98 km road linking El Obeid to Dubiebat was improved through Dutch finance from a track to an engineered gravel surfaced road between 1981 to 1983. The rapid deterioration of the gravel surfacing after completion of sections of the road convinced the Dutch and GOS that adding an asphaltic surface was desirable. Asphalt surfacing of the road will commence in 1985. The 301 km track linking Kosti to El Obeid via Um Ruwaba and Rahad is scheduled for improvement to an engineered asphaltic surfaced road with financing by USAID and ADB.

The remaining road system consists entirely of tracks. In general, the tracks developed first by pedestrian and animal traffic, followed by animal drawn and then motorized vehicles. The tracks run on natural ground and except for rare and isolated places, no improvements or maintenance exist. When a track deteriorates, truck or farm tractor operators abandon that track and create a new one. It is common for several parallel tracks to exist with vehicle operators maneuvering from one track to another, sometimes even encroaching into adjacent farm crops. In Northern Kordofan the tracks are sandy and difficult to traverse because of the lack of soil cohesion, while in the south, black cotton soils make the track impassable during the wet season. An additional impediment are water courses which, during the rainy season, are in general also impassable. This condition occurs more in the south than the north.

2. Description of Project Roads

a. Kadugli-Talodi Road

A feasibility and detailed engineering study for Kadugli-Talodi Road was completed in 1979 by Carl Bro. International a/s, Consulting Engineers. The proposed alignment is 91.6 km long and essentially follows one of the existing tracks linking the two towns. Adjacent to the selected track is a telegraph line which was taken into account by the Consultant in establishing the proposed road alignment to reduce service alterations to a minimum.

Soils investigations made as part of the study indicated that approximately 20 percent of the soils are black cotton, 60 percent silty to sandy clay, 10 percent silty fine sand and the remaining 10 percent gravelly silty sand. Because of the extent of black cotton and clay soils and ten well defined narrow watercourses (there are no existing drainage structures), during the rainy season the road is impassable to vehicles. Upon drying the black cotton soil becomes extremely hard, making travel difficult because of the hardened ruts.

Along the road six sources of natural gravel deposits could provide an estimated half a million cubic meters of pit-run gravel with an average haul distance of about 15 kms. Except for the black cotton soils the existing soils are suitable for constructing the formation and can be obtained from the immediate vicinity of the road. Material from these sections could be used as a fill source for the areas of black cotton soils.

Illustrative of the study's completed designs are sixty-nine box culverts, five bridges, and pipe culverts spaced at average density of about one per km. Proposed pipe culverts were 600 m and 1000 m diameter concrete pipes. Box culverts were of the size shown in the following table.

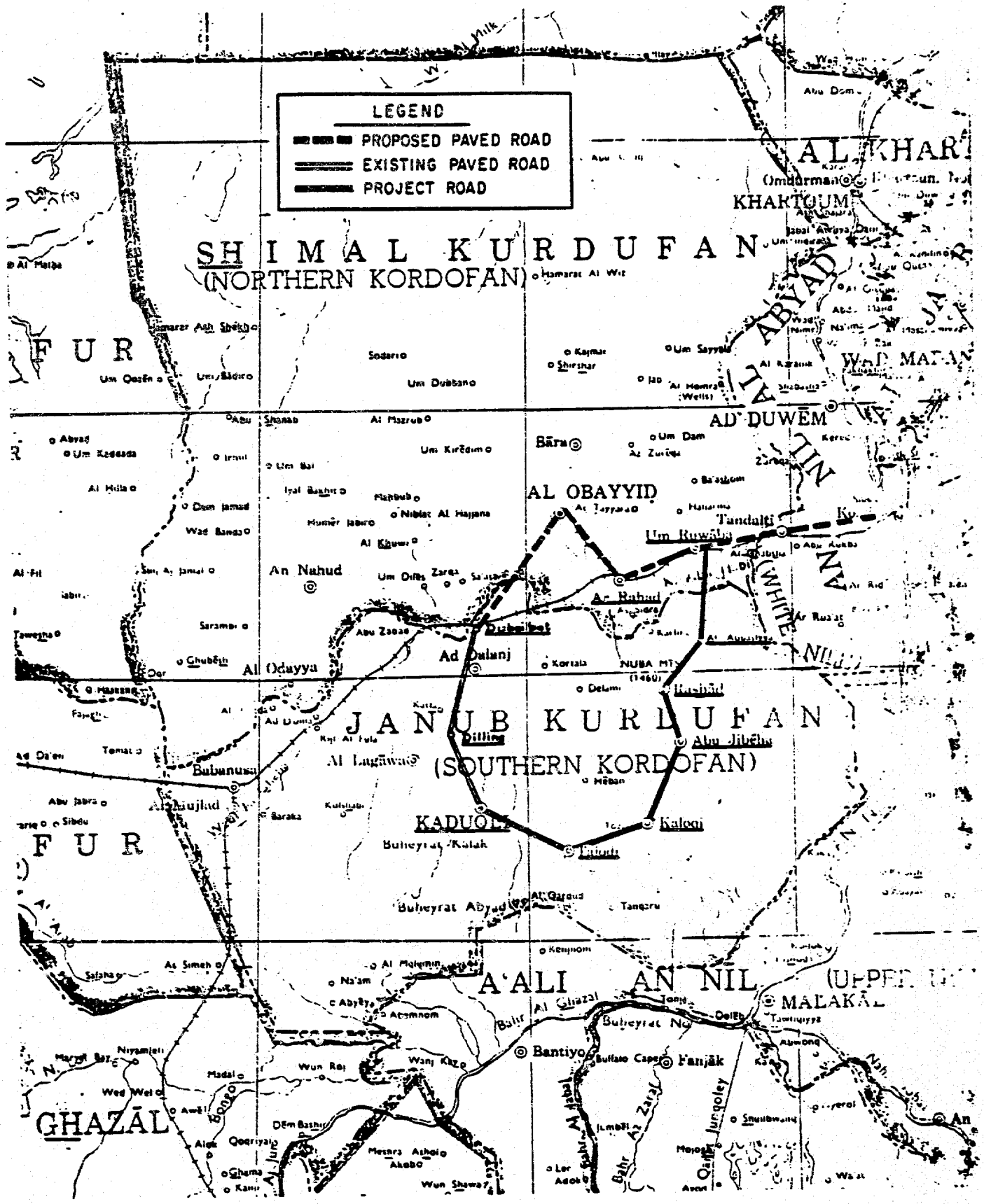
NUMBER OF BOX CULVERTS

Size of Opening (meters)	Number of openings 1	2	3	4	5	6
2 x 2	12	20	-	1	1	-
2 x 1.5	6	2	-	-	-	-
3 x 1.5	6	2	1	-	-	1
3 x 2	7	4	2	2	1	1
TOTALS	31	28	3	3	2	2

Norconsult selected a standard 12 meter bridge span with bridge lengths and spans as follows:

Location (km)	Number of Spans	Approximate Bridge Length (meters)
16.1	5	60
16.4	3	56
22.8	4	48
26.9	4	48
41.5	4	48

The study's proposed typical section provided for a 7.0 m wide carriageway, 1.5 m wide shoulders, a double seal bituminous surfacing, 150 mm thick crushed stone base and 100 to 150 mm natural gravel subbase with the thickness of subbase determined by the subgrade CBR.



LOCATION MAP

FIGURE A-1

Norconsult prepared and submitted to the Sudanese Government their cost estimate as a confidential report under separate cover from their final report. The cost estimate could not be located. Using the average cost per km[1] of Sudanese Pounds (LS) 318,438, from the economic appraisal of the Kosti - El Obeid Road which has a similar typical section, the cost of the road would be about LS 29 million (1983 cost data) if constructed to the study's design standards.

b. Talodi - Kologi Road

The terrain between Talodi and Kologi is predominantly flat with a few rocky hills rising approximately 100 - 300 meters above the plains. The plain rises gradually in elevation from about 430 meters at Talodi to 600 meters at Kologi. The track presently used is 87 km in length. The improvement length given in Sudan Feeder Roads Master Plan, May 1980, Part C, Vol. 2, Preliminary Evaluation of Project[2] is 80 km. The difference of 7 km probably resulted from new tracks being established during the rainy season by farm tractor operators who established a new alignment when the tracks became too deep or to avoid a particularly bad area in the black cotton soils.

The observed soils were estimated to be about 45 percent black cotton, 20 percent sandy clay, and 35 percent sandy to rocky soils. The Norconsult Report estimated the subgrade soils to be 88 percent black cotton and 12 percent laterite. For estimating the magnitude of road works, the surface soils have been assumed to be 70 percent black cotton, 20 percent sandy clay and 10 percent sandy to rocky soils.

Ten well defined water courses were observed. Of these only two, Khor Tosi and Khor Tuffa, warrant ultimate construction of a bridge structure. The remainder will require culverts.

Evidence of natural gravel deposits were observed in the general area. The Norconsult Report estimated 12 percent of the surface soils were laterite and that the average haul distance of pit-run subbase material was about 15 kms.

c. Kologi - Abu Gubeiha Road

The terrain adjacent to the road between Kologi and Abu Gubeiha is generally flat with a few rocky hills extending 100 to 300 meters above the plain. The elevation of the plain rises gradually from approximately 600 meters at Kologi to around 700 meters at Abu Gubeiha.

For approximately the first 25 km from Kologi the track appears to be relatively new, compared to the last 61 km which bears evidence of being in use for a long period of time. The newer alignment probably developed during the rainy seasons by farm tractor operators in a manner similar to the Talodi - Kologi Road.

(1) Prepared for USAID by Louis Berger International Inc., November 83.

(2) Prepared by Norconsult a/s, Consulting Engineers, Architects & Economists, Norway

The surface soils were estimated by Norconsult to be all black cotton soils. Observed soils were estimated to be 45 percent black cotton, 15 percent sandy clay, 25 percent laterite and 15 percent sandy. For estimating the magnitude of road works the surface soils have been assumed to be 65 percent black cotton, 20 percent laterite and 15 percent sandy soils.

Fourteen well defined water courses were observed, but only three (Khor Haboob, Wad El mileisa and Tandik) are large enough to ultimately require a bridge. The remaining 11 will require culverts.

Laterite soils were observed in the area which could be used for gravel surfacing. The Norconsult Report estimated the average haul distance for pit-run gravelly material to be 15 km.

d. Abu Gubeiha - Rashad Road

The terrain for the first 40 km north of Abu Gubeiha is predominantly flat but changes to a generally rolling terrain for the remaining 19 km to Abu Gubeiha. The adjacent area contains mountains which rise above the surrounding plains approximately 100 - 200 meters in the southern portion of the road to the higher Nuba Mountains at Rashad. The elevation of the road rises from approximately 700 m at Abu Gubeiha to around 880 m at Rashad.

The surface soils were estimated in the Norconsult Report to be 70 percent black cotton and 30 percent laterite. Observed soils were estimated to be 50 percent black cotton, 20 percent laterite, 15 percent sandy clay and 15 percent rocky. The latter observed soil classifications have been used in estimating the magnitude of the road works.

Extending north approximately 14 km from km 12 is an abandoned road formation about 4 meters in width. It was probably wider when originally constructed but reduced by erosion. Local residents stated the road was constructed around 1970. Due to the lack of maintenance, the laterite surface has numerous pot holes and is therefore not used by vehicles. The adjacent black cotton and sandy clay surface soils are smoother during the dry season.

There are 12 distinct water courses crossing the road alignment. The stream at Km 17 has a concrete surfaced ford about 10 meters in length and 4 meters wide. The surface is in poor condition. Both approaches are steep and the concrete ramp does not extend a sufficient distance. Near Km 43 is a water course, also with a concrete surfaced ford. It is approximately 60 meters in length and 5 meters wide. The concrete surface is also in poor condition with some underlying stones exposed. The approaches are steep and the concrete surfacing too short. Only one of the remaining water courses will ultimately require a bridge, with the remainder requiring culverts.

Laterite soils which could be used for gravel surfacing were observed in the area. The Norconsult Report estimated the average haul distance for pit-run gravelly material to be 15 km.

e. Rashad - El Abbasiya Road

The road for the first 40 km from Rashad traverses a plateau with numerous small stream courses crossing the alignment at an average spacing of about 1.6 kilometers. Of the 24 observed stream courses only three may ultimately require a bridge. The one located near m 13 has a concrete surfaced ford approximately 30 meters long and 4 meters wide. The approaches are steep and the concrete surface is in poor condition. The remaining 21 water courses will require a culvert.

Beginning at Km 40 the road begins to descend from around elevation 880 to 640 meters, with three distinct areas having gradients of from 15 to 20 percent. From Km 43 the road extends another 17 km to El Abbasiya. The adjacent terrain is flat.

The Norconsult Report did not give the surface soil type for this road. The observed surface soil types are 10 percent black cotton, 25 percent each of sandy clay and laterite, and 40 percent rocky. These soil distributions have been used for estimating the magnitude of the road works.

From Km 40 there are five distinct water courses, of which only the one at Km 47 will ultimately require a bridge, with culverts being required for the other four.

There appears to be an adequate supply of either laterite materials or pit-run gravel. Average haul distance is estimated to be about 5 km.

f. El Abbasiya - Balahat - Um Ruwaba Road

Direct observations were not possible on this road because of recent rains which made some of the water courses and black cotton soils impassable to vehicles. From the Norconsult Report the proposed alignment extends north from El Abbasiya, passing to the west of Barid near Km23, through Sherkeila at Km 73, and, after crossing the railroad extending west from Kosti, enters Balahat at Km 95. Balahat is located approximately 26 km to the east of Umm Ruwaba. Upon completion of the proposed improvement of the road from Kosti to El Obeid, there will be a paved road from Balahat to Umm Ruwaba. Total travel distance from El Abbasiya to Umm Ruwaba will be 112 km.

The surrounding terrain is flat with fewer well defined water courses than the other sections of road. The Norconsult Report estimated that five small bridges would be required. From observations of similar roads in the area, it is estimated that concrete fords can be constructed in lieu of the bridges. Average length of the fords (not counting approaches) is assumed to be 40 meters.

Norconsult estimated the surface soils to be 75 percent black cotton and 25 percent silty sand soils. Average hauling distance of pit-run subbase material was estimated to be 36 km.

3. Improvement of Track Roads

a. Defining the Improvement

Pre-feasibility studies completed by Norconsult concluded that, except for several high traffic tracks between market centers, rehabilitation and maintenance of existing tracks is the most cost-effective way of improving transit within Kordofan. Maintenance is defined as operations that repair or prevent damage to roads by traffic and weather, and restore the road to the level intended by the original design and construction.

Rehabilitation is defined as operations that restore roads, on which maintenance has been inadequate, to the level intended by the original design and construction. This may apply to some tracks, but not to those observed in South Kordofan. Only six stream fords, one bridge and a 14 km section of abandoned road formation were observed - these were the only engineered items having an original design or construction.

Betterment is defined as minor construction to upgrade an existing road in spot locations, or to make minor changes along the entire length of the road.

Rehabilitation and betterment operations are normally considered maintenance operations. Of the three terms however, betterment best describes project objectives and will be used as the defined operation to improve the track roads. Routine and periodic maintenance of the upgraded tracks, two essential operations, are covered in another section.

As defined in the Project Identification Document (PID) the original intended standard of construction was to improve the tracks to a standard such that routine maintenance will make them passable for from 30 to 50 percent of the rainy season without requiring additional major betterment works. It is apparent from the description of the track roads that only two major impediments are present which prevent the passage of motorized vehicles during the rainy season - water courses and black cotton soils. During the dry season, and to lesser extent the wet season, some sandy area makes the passage of vehicles difficult and occasionally impassable.

Except for large streams, the difficulty with water courses is a problem predominantly associated with Southern Kordofan. Many of the banks of water courses in the south contain black cotton soils, which, in addition to flowing water after rains, make crossings impassable during the rainy season. An exception are water courses in rocky areas.

To make a water course passable there are three options: construction of a ford[3], culvert or bridge. Because of the high cost of bridges, they are normally not considered for low cost roads except for large drainage areas having a deep water course or channel. Fords for deep channels require long approaches thereby increasing the costs to values comparable to a bridge. For example, a channel 6 meters deep would require 2 approaches not less than 36 meters in length. No deep water courses are observed on any of the tracks. Fords will be used for all drainage areas whose runoff exceeds the capacity of

(3) Covering the bottom of a water course with rock overlaid with concrete. Approaches are normally constructed with slopes not greater than six horizontal to one vertical.

a culvert except that for large culverts a cost comparison should be made during final designs to determine if significant savings can be obtained by use of a ford.

Table A-1 gives the average monthly rainfall and the number of days during which there was rain. Although to the north of the project area, the data can be used as a guide. Assuming the same rainfall patterns, all water courses having culverts would be passable the entire year, and fords passable except during high water flows which are estimated to last from 3 to 4 hours. Even if this should occur for example every day of a four month rainy season, the ford would be passable 94 percent of the year and 83 percent of the wet season.

The remaining problem in the south is passage through black cotton soils. Historically, black cotton soils make portions of the road impassable for an average of four months during the rainy season to all vehicles except farm tractors. These areas must therefore be improved with a road formation constructed of suitable material, overlaid with pit-run gravel surfacing, and adequate routine maintenance performed to fill and repair holes as they develop under traffic. Soft and/or shifting sand areas are a problem in the north, and in particular to that portion of the project roads extending south of Balahat towards Barid.

If multiple parallel tracks are to be prevented, a final alignment established and the road made passable, the sands must first be levelled and then overlaid with a road formation approximately 500mm thick, made of material suitable for road construction. The formation will require a gravel surfacing to permit passage during the rainy season.

An average of 50 percent of the project roads' surface soils is black cotton and 20 percent sandy clay. A quote from the Norconsult Report states: "During the rainy season large areas (clay areas) are impassable and cannot be made passable without some form of engineered road, i.e. a properly constructed roadway structure with drainage and bridge works. Consequently, there appears to be no intermediate standard that can improve accessibility during the wet season". The presence of such a large percentage of unstable soils confirms the Norconsult Report's finding of the need to provide a properly constructed engineered road.

b. Design Standards

The improvements major cost component is earth formation and gravel surfacing with costs being directly proportioned to the roadway width. For example, reducing the roadway width by 50 percent reduces the volume of earthworks and gravel by nearly 50 percent. It is possible that some roads normal traffic densities may not justify a width greater than a single lane, with provisions for passing lay-byes at appropriate intervals. Nevertheless, a 5.5 m wide roadway has been selected in lieu of a 4 m roadway for the following reasons:

- The wider roadway provides greater protection against deterioration of the road edges resulting from rain and traffic using the roadways outer edges.

- reduces depth of surface rutting due to channelization of traffic,

- the uncertainty concerning the performance and/or effectiveness of road maintenance, and

- 5.5 m (18 ft) is one of the more commonly used roadway widths in rural areas,

Construction costs are approximately 23 percent greater for a 5.5 m wide roadway section than for a section 4 m wide and about 6 percent less than for a 6 m wide section. The cost differential is not on a straight line since the cost for some items such as ditch construction, clearance of right-of-way and one-way fords do not vary with roadway width. The analysis of cost difference is given in Attachment A.

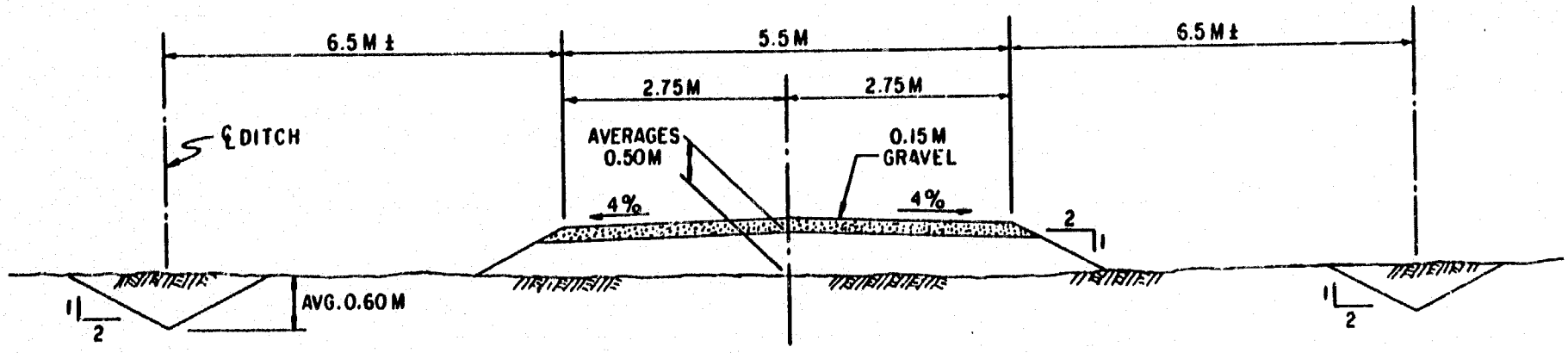
The proposed typical section is shown on Figure A-2.

The height of the formation will average approximately 500 mm with greater heights possibly being required at culverts, low lying areas, and expansion-prone black cotton soils.

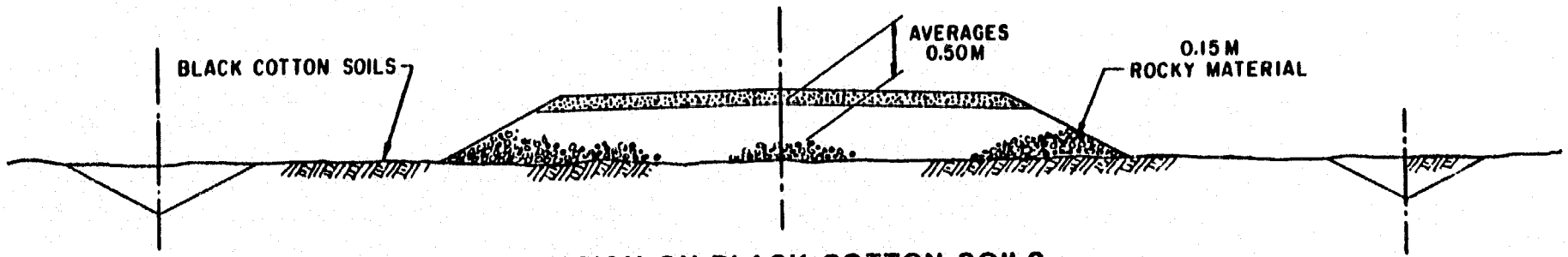
Because most of the surface soils are prone to severe erosion when water is concentrated, the centerline of side ditches is located approximately 6.5 meters from the edge of the roadway to prevent and/or reduce the liklihood of erosion occuring adjacent to the formation. To prevent high concentration of runoff, ditches will be turned away from the road to natural drains as often as terrain will allow. A schematic sketch showing a typical ditch plan is present on Figure A-3.

During the dry season the gravel surfacing ruts and corrugates due to a large extent from the loss of fine, binding material by not only wind and the passage of vehicles but also to the lack of moisture which makes the surfacing materials non -cohesive. Keeping the surface smooth during the dry season is practically impossible and as a consequence, in the flat area common to the Kordofan Region, drivers leave the gravel surface to find smooth and hardened black cotton or sand clay soils. This practice is not without benefits since it reduces gravel losses and continual blading of the gravel surface. Because of adjacent farm lands, however, it needs to be controlled.

The area between the top of the inside slope of the side ditch and the toe or bottom of formation slope is approximately 4 m. At the end of the rainy season before the soils harden, the area on each side of the formation should be graded to make smooth (sloped toward ditch for proper drainage) for use by vehicles during the dry season. The side ditches will act as a deterrent to keep the driver within the roadside area.



TYPICAL SECTION

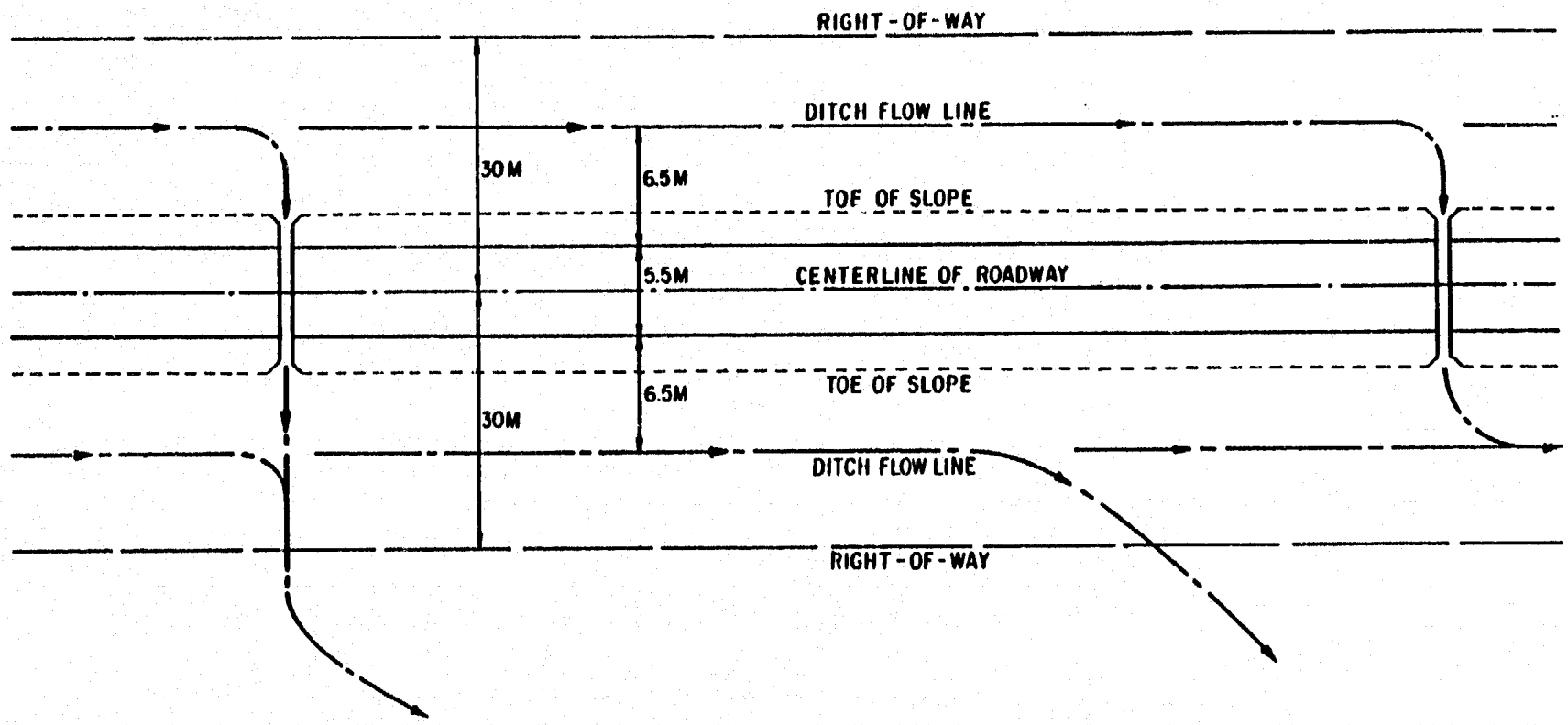


SECTION ON BLACK COTTON SOILS

NOTE:
NOT TO SCALE

TYPICAL ROADWAY SECTIONS

FIGURE A-2



PLAN OF TYPICAL SIDE DITCH

FIGURE A-3

Most of the surrounding terrain is relatively flat, but with some cross slope. As a consequence sheet flow[4] runoff is common. There is therefore a need for small drainage structures to pass the sheet flow collected in the side interceptor ditches at fairly regular intervals beneath the road. An average of two 600 mm diameter pipe culverts will be required per km with every third installation being a double pipe culvert. A 600 mm diameter pipe is considered the minimum size pipe that can be easily maintained. Concrete pipe of this size can be manufactured on site. It is normally a fairly weak pipe and must be constructed with surrounding concrete. The 600 mm size pipe can be handled by labor thereby reducing the mechanized equipment requirement and increasing the amount of local employed labor force.

The inventory of definable water courses indicates that approximately 21 water courses will require a ford and 155 will require culverts. A proposed cross section of the ford is shown on Figure A-4. The approaches to the ford will have the same general cross section as the ford but with a probable reduction in depth of cut-off wall. The approaches will extend from the end of the ford, on a maximum slope of 1 to 6, to a point above high water or to level ground. The ford's cutoff wall should extend below scour depth[5]. Gabions would be placed on each side of the ford. The construction of the proposed ford does not require sophisticated equipment or methodology as compared to a bridge, is less costly than a bridge, reduces the amount of equipment and increases the use of local employed laborers.

It is proposed for the remaining 155 or so definable water courses than an open-bottomed culvert with masonry abutments and a reinforced concrete slab be used. A cross section of a typical culvert is shown in Figure A-5. This 4.6 m span culvert has been used for estimating project costs. It is envisioned that during final designs, smaller and possible larger variations will be developed. The smaller size may replace larger box culverts included in the construction cost estimates. These structures, although not significantly less costly than box culverts, are generally less costly where labor and masonry materials are cheap and readily available. They minimize the requirement for equipment, skilled labor, forming and reinforcing steel, but increase the demand for local labor.

Results of 48 hour soaked CBR[6] tests performed on black cotton soils along the Kosti - Umm Ruwaba Rd. gave values varying from 2 to 7. Other tests gave an average plastisity index (PI)[7] value of 23, and liquid limit (LL)[8] value of 44. The PI of black cotton soils along the Kadugli - Talodi Road averaged about 33 and LL about 59. Four-day soaked CBR values were not reported but the report gave an indication

(4) Depth of runoff from rains is fairly uniform over the areas.

(5) Depth to which material in stream bed becomes more or less fluid during runoff from rain storms.

(6) California Bearing Ratio (CBR) is a comparative measure of the shearing resistance of a soil. Is a commonly used indicator of the strength of a soil. The higher the value the more suitable for road construction.

(7) Plastic Limit of a soil is the lowest water content at which the soil remains plastic.

(8) Liquid limit of a soil is that water content at which the soil passes from a plastic to a liquid state.

that values were below 2. Unsoaked CBR values along the Kosti -Umm Ruwaba Road varied between 7 and 12. The need to have side ditches on each side of road formation to reduce the possibility of subsoil saturation beneath the embankments is self evident.

To give additional stability in black cotton soil areas and in particular highly expansive soils, provisions should be made for an initial layer of rocky material beneath the formation. Evidence of this type of construction can be seen under the formation between Abu Gubeiha and Rashad which was abandoned for non-maintenance of the surfacing rather than a formation failure.

For project construction cost estimates, a 150 m layer has been assumed. This type of construction should be further investigated during final design.

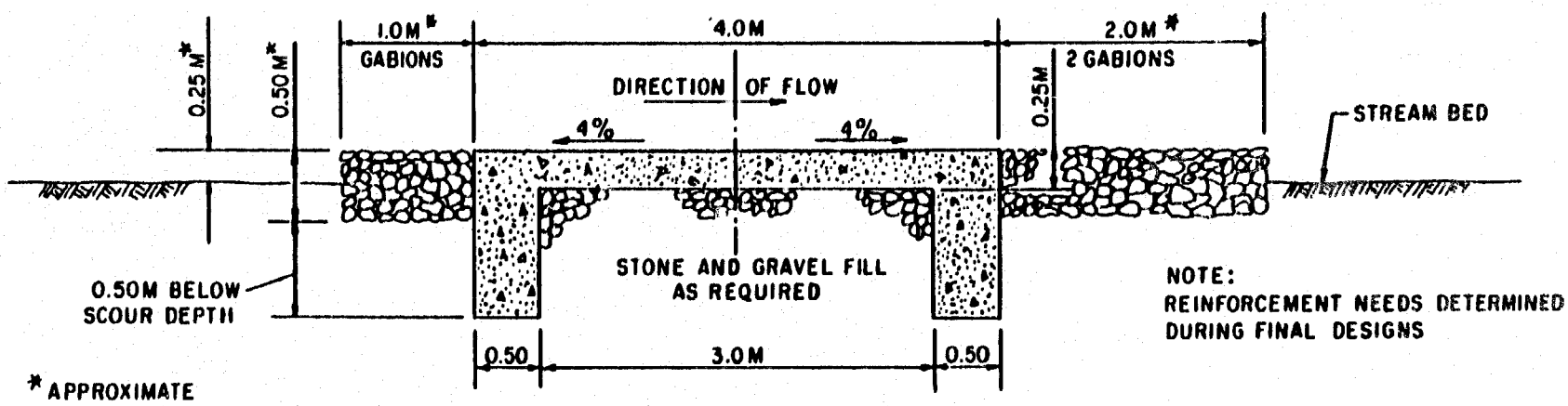
Design Methodology

The existing tracks for most project roads are not well defined and as a result there will be considerable latitude in the establishment of final alignments. Such items as established farms, villages, rock outcrops, stream crossing and, where possible, avoidance of particularly bad soil areas but at the same time following the general direction of existing tracks will, to a large extent, set the design alignment. Problems with horizontal curvature should not occur. Because most of the area is relatively flat the road formation will generally be fill rather than a cut section. The vertical alignment will therefore be relatively simple to design.

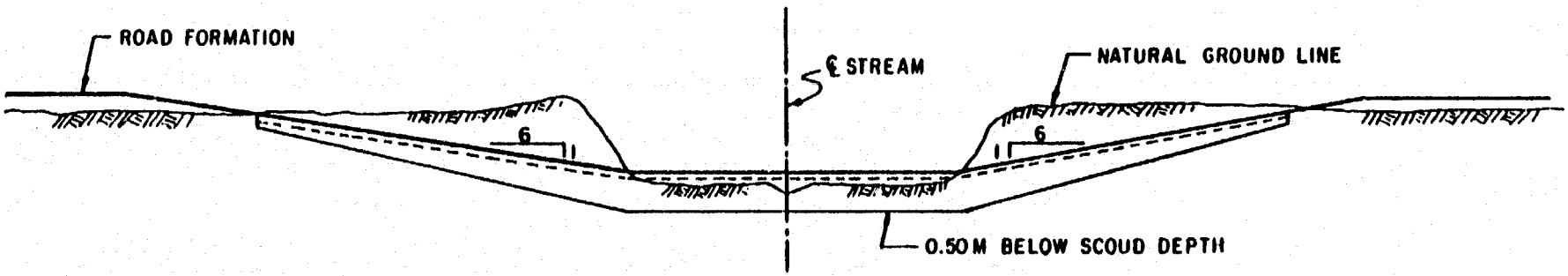
Earthworks and gravel surfacing combined accounts for 72 percent of the estimated construction costs. We consider our estimated earthwork quantities to be accurate within a range of plus or minus 15 percent and gravel surfacing plus or minus 5 percent.

A combined error of 25 percent in the cost estimates for the remaining work items would result in overall error of approximately 7 percent in the overall estimate. We consider our estimates to be accurate within this range of plus or minus 5 percent in the overall estimate.

Because of the remoteness of the area and the lack of accurate and/or large scale mapping and soils survey data, the cost of detailed field surveys and final design plans would be practically the same as those prepared for higher standard roads. For project relatively low cost roads, we consider the need for detailed plans normally expected and prepared prior to construction to be unnecessary.

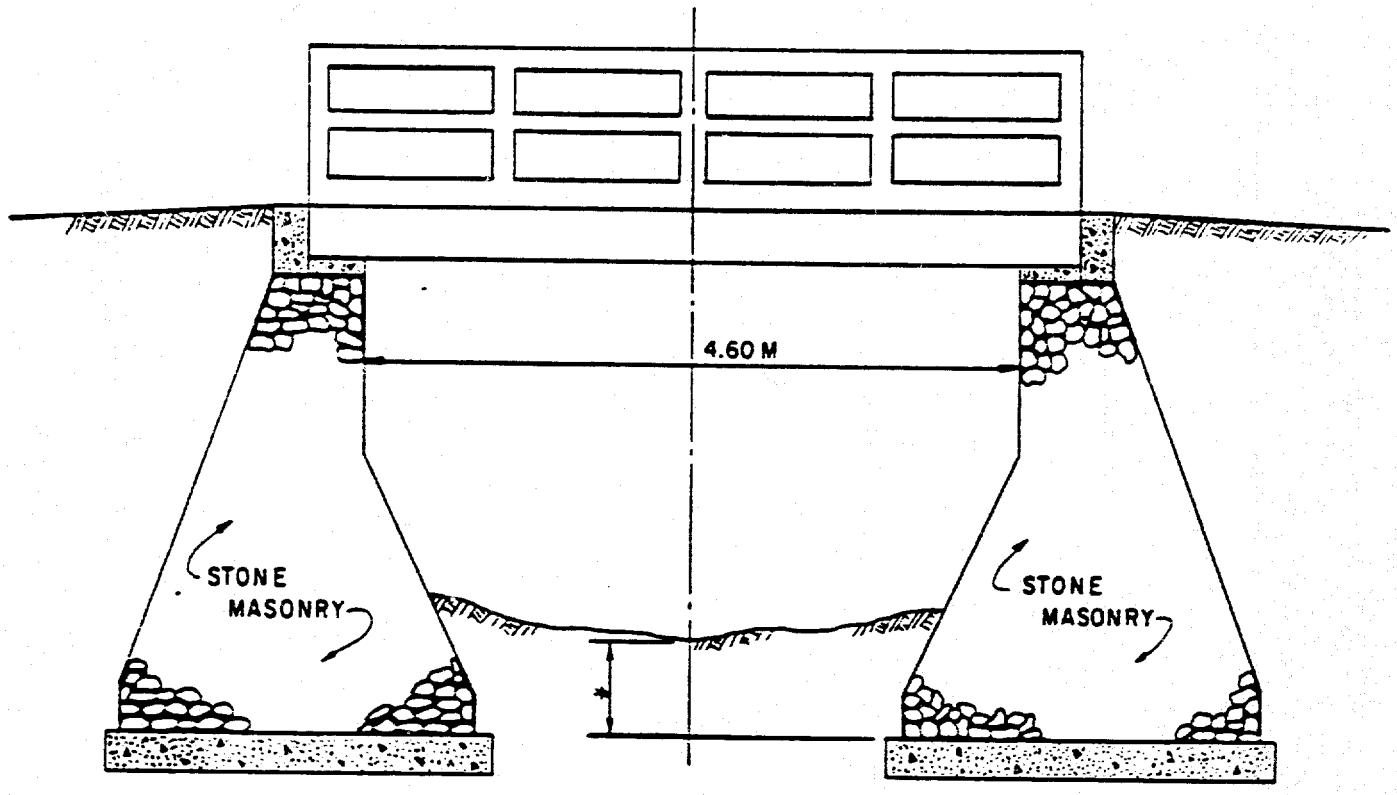


TYPICAL SECTION OF FORD



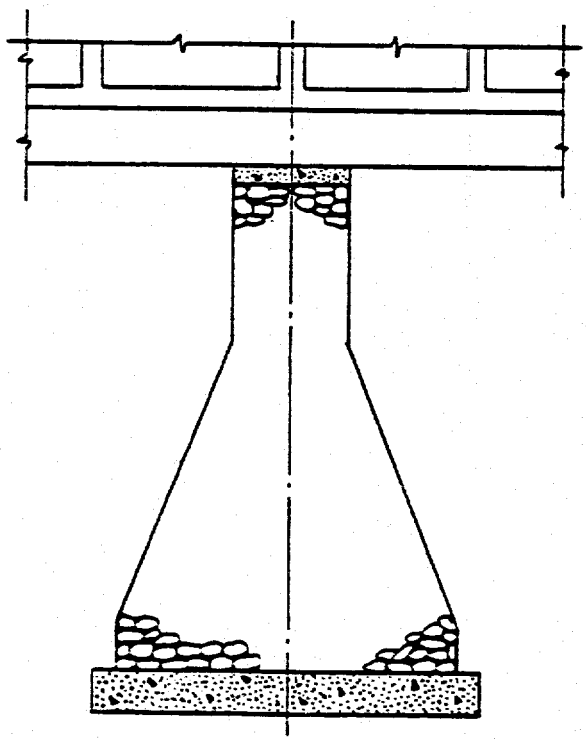
LONGITUDINAL SECTION OF FORD

FIGURE A-4



SECTION OF SINGLE SPAN CULVERT

* Minimum Of 0.05 M Below Scour Depth



PIER FOR MULTIPLE SPAN CULVERT

TYPICAL OPEN CULVERT

FIGURE A-5

We therefore propose that standard drawings of pipe, box and open-bottom culverts, fords, ditches, erosion control measures and other similar details be prepared during the first stage of the project. Quantities would be computed for multiple applications of these standard units. Because of the terrain, the number of different applications will not be significant.

Whole standard details are being prepared the alignment for the first phase of construction (see Construction Implementation) will be established in the field,only major topographic features noted and a surveyed center-line profile of existing ground obtained. Additional profiles at major stream crossing may also be taken.

The Soils Engineer will be locating sources of supply for select materials, pit-run gravel, laterites and sand and gravel for cement mortars and concrete. These will be established for all the project roads during the Soils Engineer's contemplated single assignment.

The Drainage Engineer in a similar manner will establish drainage areas and runoffs, using available mapping and agriculture aerial photos, for all major streams. Using the stream cross section, high water marks from observation and discussion with local people, and flowline gradients, stream flow quantities will be determined for definable water courses. Because more than 170 water courses were noted during our field reconaissance, it is probable that stream flows will not be established during the Drainage Engineer's proposed single assignment. He will, however, establish the procedures and methodologies so that resident staff can complete stream flows for the remaining streams.

Line drawings showing horizontal and vertical designs, standard detail drawings and a bill of quantity of construction items will form the design input to the contract documents for competitive negotiations with local Sudanese contractors. Exact positioning of pipe, box and open-bottom culverts and fords will be established during construction. It is probable that minor changes to vertical alignments will be required as drainage flow line are finalized and as a consequence road profile adjusted to fit the drainage structure.

The design of subsequent phases will continue in a similar manner (with refinements made as appropriate) for the life of the project. As a result design costs will be low in keeping with the standard of road being constructed. Because many design features will be determined and/or finalized on site,the resultant product should conform closely to local needs and conditions.

B. Detailed Construction Cost Estimates

1. Introduction

Detailed construction cost estimates are based upon unit price values, and equipment and vehicle hourly operating costs developed by Norconsult for the 1980 Feeder Road Study and the Kosti - El Obeid Road, the Berger update study of the Kosti - Umm Ruwaba Road, and the 1974 Road Maintenance Program prepared by Berger. All costs were escalated by the following rates. The rates were derived from rates used in cited reports, in particular the Kosti - Umm Ruwaba Road study, and World Bank rates[9] from 1984 foreward:

Year	Annual Escalation Rates - %
1974-78	23
1979-82	27
1983	22
1984	17
1985	15
1986	13
1987 fwd	13

2. Unit Prices

Base unit prices of work tasks that best described the work tasks involved in the betterment of project track roads were taken from the cited reports and studies. These were escalated to January 1985 for use in preparing construction cost estimates

(9) Rates used for IBRD Third Highway Project Paper.

	Item	Unit	Jan 1985 Unit Price (Sudanese Pounds)
1.	Clearing and Grubbing	m^2	0.18
2.	Embankment In Place	m^3	3.00
3.	Select Mat'l In Place	m^3	4.00
4.	Excavation of Ditches	m^3	2.50
5.	Pit-run Gravel Surfacing, 1 km Haul	m^3	8.00
6.	Haulage	m^3/km	0.50
7.	Concrete, Plain	m^3	150.00
8.	Concrete, Reinforced	m^3	190.00
9.	Reinforcing Steel	kg	2.40
10.	Stone Masonry	m^3	65.00
11.	Rip Rap	m^2	8.00
12.	Rock Excavation	m^3	20.00
13.	Foundation Excavation	m^3	11.50
14.	CMP Culvert, 1000 mm	m	110.00

3. Estimated Construction Costs per Kilometer

To develop construction cost estimates for each road section, we estimated per kilometer costs for earthworks, minor drainage and gravel surfacing. Costs for box culverts, open-bottom culverts and stream fords were developed on an estimated incidence basis.

a. Earthworks

Using a gravel surfacing width of 5.5 m with a thickness of 150 mm and 2:1 side slopes gives a subgrade formation width of 6.1 m. Because most of the terrain is flat and there will be little to no roadway excavation, an average formation height of 0.50 m was assumed. This gives a required borrow volume of 3,550 m^3/km. In some areas materials adjacent to the road are suitable for the construction of the formation. The formation will average only 0.50 m in depth which is shallow especially in black cotton and clay soils areas. To insure the use of a more select material in these areas an average haul distance of 10 km, based upon field observations, has been used.

Ditch excavation is estimated to be 1.44 m^3/m. For estimating costs it was assumed that ditches are continuous and the excavation is wasted or placed on sideslope (black cotton soil material) for growing of grass and slope protection. These two assumptions are not completely true, inasmuch as ditches may or may not be continuous and some ditch excavation may be suitable for formation construction. The error, however, is estimated to be small and on the conservative side. It has therefore been disregarded. GOS's established right-of-way width is 30 meters each side of road centerline. For determining clearing and grubbing, only 15 m each side of centerline is to be cleared which is approximately 4 meters beyond top of the side ditch. This will provide an additional dry weather travelway on the hardened clays. To the subtotal an amount has been included for miscellaneous work such as erosion control, and to 'round' the cost estimate:

ESTIMATED EARTHWORKS COSTS PER KILOMETER

(Sudanese Pounds)

Item	Cost
Formation: 3,550m^3 x LS 3.00/m^3	10,650
Side Ditches: 1,440m^3 x LS 2.50/m^3	3,600
Overhaul: 3,550m^3 x 10 km x LS 0.50/m^3km	17,750
Clearing & Grubbing: 30m x 1000m x LS 0.18/m^2	5,400
Erosion Control and Other Misc. Earthworks	2,600
Total	40,000

b. Foundation for Formation in Black Cotton Soil Area

To give additional stability in black cotton soil areas and in particular highly expansive soils, provisions have been made for an initial layer of rocky material. Evidence of this type of construction can be seen on the abandoned formation between Abu Gubeiha and Rashad. This formation was abandoned for non-maintenance of the surfacing rather than formation failure. For cost estimates, a layer approximately 150 mm thick was used between the formation and the black cotton soils. This type of construction should be further investigated during final design. A unit cost of LS 5 per m^3 plus 10 km haulage of LS 10 per m^3 gives an estimated per km cost, 'rounded' of LS 13,000.

c. Concrete 600 mm Pipe Culverts

We estimate an average of two concrete surrounded 600 mm concrete pipe culverts per km are required, but with every third installation being a double pipe of the same type construction. The estimated cost per single pipe culvert is LS 800 giving an average per km cost of LS 2,100 for pipe culverts.

4. Open-Bottom Masonry Abutment Culverts

During observation of the roads, all well defined water courses were noted. For the 'defined' channels having drainage areas whose estimated runoff requires a culvert opening from approximately 10 to 30 m^2, the use of a culvert with masonry abutments (and piers if more than one span), a reinforced concrete deck, and natural stream bed bottom is proposed. The derivation of the estimated cost of a single 4.6 m span culvert is given in the following table.

ESTIMATED QUANTITIES AND COSTS
TYPICAL SINGLE 4.6 M SPAN OPEN-BOTTOM CULVERT

Work Item	Unit	Quantity	Unit Price LS	Amount LS
Stone Masonry	m^3	93	65.00	6,045
Reinforced Concrete	m^3	15.1	190.00	2,869
Plain Concrete	m^3	18.2	150.00	2,730
Reinforced Steel	kg	1936	2.40	4,646
Str. Excavation	m^3	270	11.50	3,105
Railing, Back Filling, Etc.	-	-	-	2,605
				LS22,000

The cost of a double 4.6 span structure is not twice the cost of a single span structure since the cost of substructure (piers and abutments) is increased by only the cost of a single pier. Similarly a three span structure's substructure is increased by the cost of two piers. Total estimated cost of a typical double and triple span structure is LS 36,000 and LS 50,000 for the two structures respectively. Since the drainage areas for the 'defined' water course has not been determined, the ecact size of structure will not be known until final designs. For cost estimating purposes the average cost of LS 36,000 was used for each 'defined' water course.

5. Concrete Box Culverts

During the final design it is probable that drainage areas will be found that are too large for a pipe culvert and too small for an open-bottom culvert. Using the completed final designs for the Kadugli-Talodi Road as a guide, we estimate that an average of one 2 x 1m and one 3 x 1m box culvert will be required every 3 km. This estimate includes those water courses where open-bottom culverts are proposed. The number of open-bottom culverts must be subtracted from the estimated number of box culverts. Using an estimated cost of LS 760 per m^2 of culvert and culvert length of 6.5 m times the total span of the box culverts, gives the estimated cost of box culverts.

For example, a 60 km long road with 12 open-bottom culverts would have 60 divided by 3 less 12 or 8 box culverts. The estimated cost would be LS 760 x 6.5 x 8 (2+3) ½ = LS 98,800.

6. Fords for Water Courses

From the observed size of stream channels those that would require a bridge were estimated. Becuase of low traffic volume and the need to keep construction costs low, fords have been used in lieu of bridges. Fords are to be constructed 4.0 m wide, with concrete cutoff walls, and a concrete surface overlying hand-placed rock and gravel between the cutoff walls. Gabions would be placed on each side as shown on Figure A-3. Approaches of generally the same construction will extend on a maximum grade of 1 to 6 to a point above high water or level ground if the stream has overflowed its banks. Estimated cost of a ford is LS 600 per meter of length of ford including the approaches.

7. Financial Construction Cost Estimates

Tabulated in Table B-1 are the improvement length, length of black cotton soils, estimated January 1985 financial cost of earthworks, gravel surfacing, culverts, fords, and miscellaneous works for each of the 9 sections of road. The total estimated financial cost of all the roads is LS 36.8 million, which is equal to US$17.5 million at the official exchange rate of LS 2.10 per US$1.00, and US$15.3 million at a LS 2.40 rate. The average per km cost of the roads is LS80,800.

The last three sections of road have average per km costs substantially higher than for the other sections. The soils along Road Sections 7 and 8 from El Abbasiya to Sherkeila are nearly all black cotton. The average earthworks cost per km of all sections is LS45,200 compared to LS 52,500 for sections 7 and 8. The average cost of fords per km of all sections is LS 2,700 and for Section 8 LS5,870. The high per km cost of Section 9 is caused by the high cost of box culverts and fords and, drainage crossing for the wide flood plain of the Abu Rakheis River. Using average per km costs instead of the cited high per km costs would result in per km costs of LS 85,600, LS 82,700 and LS 76,100 for road sections 7, 8 and 9 respectively.

8. Estimated Economic Construction Costs

The economic costs are estimated to be 84 percent of the financial costs (based upon Norconsult's 1978 Feasibility Study of the Kosti-Umm Ruwaba Road). Tabulated in Table B-2 are the estimated economic construction costs for each of the road sections. Also tabulated in Table C-2 are the estimated 1st and 2nd year expenditures based upon 60 and 40 percent of the work being completed in the two years respectively.

TABLE B-1

SUMMARY OF ESTIMATED 1985 FINANCIAL CONSTRUCTION COSTS

ROAD BETTERMENT FOR KORDOFAN RAINFED AGRICULTURE PROJECT

(Thousand Sudanese Pounds)

Road Section	Improved Length (Km)	Black Cotton (Km)	Earth-works	Gravel Surface	Pipe Cul.s	Box Cul.s	Open Box Cul.s	Fords	Sub-Total	Misc. +10%	Total Cost	Cost Per Km
1. Kadugli-Talodi	91.6	18.3	3,907	1,191	192	855	-	297	6,442	648	7,090	77.4
2. Talodi-Shagrabeh	53	30	2,519	689	111	297	174	-	3,790	370	4,160	78.5
3. Shagrabeh-Kalogi	27	6	1,160	351	57	48	182	126	1,924	196	2,120	78.5
4. Kalogi-Abu Gubeiha	83	54	4,038	1,079	174	571	261	218	6,341	639	6,980	81.2
5. Abu Gubeiha-Rashad	56	28	2,146	728	113	272	232	131	3,627	363	3,990	71.3
6. Rashad-El Abbasiya	60	6	2,480	780	126	-	725	163	4,274	426	4,700	78.3
7. El Abbasiya-Barid	23	23	1,226	299	48	124	174	135	2,006	204	2,210	96.1
8. Barid-Sherkeila	50	45	2,599	650	105	420	232	90	4,096	404	4,500	90.0
9. Sherkeila-Balahat	12	4	536	156	25	174	-	68	959	91	1,050	87.5
Totals	455.6	214.3	20,611	5,923	956	2,761	1,980	1,228	33,459	3,341	36,800	80.8
Percent of Totals	100	47	56	16	3	8	5	3	91	9	100	-

Table B-2

SUMMARY OF ECONOMIC CONSTRUCTION COST ESTIMATES
ROAD BETTERMENT FOR KORDOFAN RAINFED AGRICULTURE
PROJECT

Section	Economic Cost (Sudanese Pounds)	60% 1st Year	40% 2nd Year
		(1000 Sudanese Pounds)	
1. Kadugli-Talodi	5,955,600	3,573.4	2,382.2
2. Talodi-Shagrabeh	3,494,400	2,096.6	1,397.8
3. Shagrabeh-Kologi	1,780,800	1,068.5	713.3
4. Kologi-Abu Gubeiha	5,863,200	3,517.9	2,345.3
5. Abu Gubeiha-Rashad	3,351,600	2,011.0	1,340.6
6. Rashad-El Abbasiya	3,948,000	2,368.8	1,579.2
7. El Abbasiya-Barid	1,856,400	1,113.8	742.6
8. Barid-Sherkeila	3,780,000	2,268.0	1,512.0
9. Sherkeila-Balahat	882,000	529.2	352.8

9. Salvage Value

At the end of the 20 year economic appraisal period a road will have a salvage or residual value. The salvage value of the project feeder roads was determined by estimating the value of major work component as a percentage of its original constructed cost value. Use was made of values given to Norconcult's 1980 Kosti-El Obeid Road Study and Berger's 1974 Road Maintenance Report to obtain the following values.

Work Item	Salvage Value As Percentage of Original Cost
1. Earthworks	80
2. Gravel Surfacing[a]	70
3. Pipe Culverts	70
4. Box Culverts	80
5. Open-Bottom Culverts	50
6. Fords	60
7. Miscellaneous	60

(a) Assumes maintenance is performed as per maintenance schedule and cost, developed and incorporated as a project cost in the economic analysis.

Tabulated in Table B-3 are the estimated salvage values for project roads.

TABLE B-3

SUMMARY OF ECONOMIC SALVAGE VALUES AFTER 20 YEARS

ROAD BETTERMENT FOR KORDOFAN RAINFED AGRICULTURE

PROJECT

Road	Salvage Value Thousand Sudanese Pounds
1. Kadugli-Talodi	4411.7
2. Talodi-Shagrabeh	3810.2
3. Shagrabeh-Kalogi	1284.4
4. Kalogi-Abu Gubeiha	4357.1
5. Abu Gubeiha-Rashad	2469.6
6. Rashad-El Abbasiya	2802.2
7. El Abbasiya-Barid	1354.9
8. Barid-Sherkeila	2819.9
9. Sherkeila-Balahat	687.1

C. Road Maintenance Costs

1. General

Maintenance does not alter or change any standards but repairs or prevents damage caused by the action of traffic and weather, and restores the road to the level intended by the original design and construction. Maintenance operations can be classified under a variety of headings, but the generally accepted most important operations are routine and periodic maintenance.

Routine maintenance consists primarily of operations performed at intervals of less than one year and is sub-divided into Basic and Variable Maintenance. The tasks for a gravel surfaced road are as follows:

Basic Maintenance

- Control of erosion
- Vegetation control
- Cleaning of ditches and drainage structures
- Repair of pot holes. (Also included in Variable Maintenance)

Variable Maintenance

- Grading and compaction of surfacing
- Repair of pot holes

Periodic Maintenance for a gravel road is the periodic replenishing, grading and compaction of gravel surfacing material.

2. Maintenance Costs

a) Basic Routine Maintenance

This task consists in the cleaning of drainage ditches and structures, erosion control, vegetation control and repair of pot holes. We estimate that a crew can maintain an average of one km every ten hours and that an average of two passes per year are required. The estimated economic cost per hour for performing basic routine maintenance is given in Table C-1.

b) Variable Routine Maintenance

This task is the annual periodic grading and compaction of the existing gravel surface. We estimated that this work will be done a minimum of twice a year (once before the rainy season and once after) and that the rate of progress is 0.50 km per hour. Table C-2 gives the estimated economic hourly cost for performing variable routine maintenance.

Table C-1

BASIC ROUTINE MAINTENANCE COST ESTIMATE
(Sudanese Pounds)

Item	No.	Economic Cost per Hour Labor	Equipment
1. Foreman	1	1.23	-
2. Driver	1	0.83	-
3. Laborers	10	4.10	-
4. Pick-up truck	1	-	10.80
5. Misc.hand tools	-	-	0.
Sub Total		6.16	10.92
6. Direct cost		17.08	
7. Indirect cost 25%		4.27	
Total Basic Maintenance Hourly Costs		Ls.21.35	

The annual per km cost for basic routine maintenance is 2 passes per year x 10 hours per km x Ls.21.35 per hour = Ls.427 per km per year.

Table C-2

VARIABLE ROUTINE MAINTENANCE COSTS
(Sudanese Pounds)

Item	No.	Economic Cost per Hour Labor	Equipment
1. Grader	1	-	22.50
2. Tractor w/trailer	2	-	15.80
3. Towed roller	1	-	15.00
4. Water tank, towed	1	-	2.70
5. Pick-up truck	1	-	10.80
6. Misc. hand tools	-	-	1.94
7. Foreman	1	1.23	-
8. Operators	3	2.70	-
9. Drivers	1	0.83	-
10. Laborers	10	4.10	-
Sub Total		8.86	68.79
11. Direct cost		77.65	
12. Indirect cost 25%		19.41	
Total Variable Maintenance Hourly Cost		Ls. 97.06	

c) Periodic Maintenance

Periodic maintenance is the replenishment, grading and compaction of the gravel surface. For the estimation of costs we estimated that 10mm of gravel is lost per year and is replaced about every five years. The volume of gravel to be replaced is 0.05m(1000m) 5.5m or 275m^3 per km. Using an average haul distance of 15 km, an average round trip speed of 25 kph, 6m^3 (compacted volume) trucks, and a rate of progress of one km every 8 hours results in a requirement for five tipper trucks. The estimated economic cost per hour for doing periodic maintenance is given in Table C-3.

Table C-3

PERIODIC MAINTENANCE COST ESTIMATE
(Sudanese Pounds)

Item	No.	Economic Cost per Hour: Labor	Equipment	Material
1. Tipper truck, 7m^3	5	-	96.50	-
2. Front-end Loader	1	-	46.58	-
3. Grader	1	-	22.50	-
4. Tractor w/trailer	3	-	23.70	-
5. Towed roller	1	-	15.00	-
6. Water trailer, towed	2	-	5.50	-
7. Pick-up truck	1	-	2.80	-
8. Foreman	1	1.23	-	-
9. Operators	5	4.50	-	-
10. Drivers	6	4.98	-	-
11. Laborers	10	4.10	-	-
12. Misc. tools	-	-	2.00	-
13. Materials	-	-	-	275.00
Sub Total		14.81	214.58	275.00
14. Direct costs			504.39	
15. Indirect costs 25%			126.10	

Total Periodic Maintenance Cost Ls. 630.49 per hr
Total Periodic Maintenance Cost 5,043.90 per km/5 years

3. Summary of Maintenance Costs

Tabulated in Table C-4 are the estimated annual economic and financial maintenance costs for maintaining one km of project roads. Economic costs are estimated to be 84 percent of financial costs (Norconsult, Kosti-Umm Ruwaba Study).

Table C-4

ECONOMIC & FINANCIAL MAINTENANCE COSTS
ROAD BETTERMENT KORDOFAN RAINFED AGRICULTURE PROJECT
(Sudanese Pounds)

Maintenance Type	Annual Cost per Kilometer	
	Economic	Financial
1. Basic Routine	427	508
2. Variable Routine	388	462
3. Periodic	1,009	1,200
Totals	1,824	2,170

Table C-5 summarizes the economic routine and periodic maintenance costs for each of the project roads.

Table C-5

ECONOMIC MAINTENANCE COST ESTIMATES
ROAD BETTERMENT KORDOFAN RAINFED AGRICULTURE PROJECT
(Thousand Sudanese Pounds)

Road Section	Length	Annual Routine	Periodic(1)
1. Kadugli-Talodi	91.6	74.7	462.0
2. Talodi-Shagrabeh	53.0	43.2	267.3
3. Shagrabeh-Kalogi	27.0	22.0	136.2
4. Kalogi-Abu Gubeiha	83.0	67.6	418.7
5. Abu Gubeiha-Rahsad	56.0	45.6	282.5
6. Rashad-El Abbasiya	60.0	48.9	302.6
7. El Abbasiya-Barid	23.0	18.7	116.0
8. Barid-Sherkeila	50.0	40.8	252.2
9. Sherkeila-Balahat	12.0	9.8	60.5
Totals	455.6	371.3	2298.0

(1) Every 5 years

D. Construction Implementation

1. General

Four methods or schemes for constructing project roads have been proposed: construction by (1) Roads and Bridges Public Corporation; (2) American Contractor; (3) joint venture between American and Sudanese contractors and; (4) Sudanese contractor. Past road construction has been accomplished by the first two methods (plus foreign contractors other than American) but none by the last two. Although some work has been done by local contractors on a subcontract basis, the work was primarily materials haulage which did not result in any meaningful highway construction experience.

2. By Road and Bridges Public Corporation

In 1984 there are approximately 2570km of paved roads whose maintenance is the responsibility of RBPC. In addition to this maintenance responsibility, in 1985 RBPC will be involved in supervising the paving of the 94km road from Dubiebat to El Obeid, in 1986 to 1989 the construction of a paved road from Kosti to El Obeidm abd as part of this project, the rehabilitation of the existing paved road extending north 186 km from Kadugli to Dubiebat. The maintenance of all these roads will ultimately become the responsibility of RBPC.

The IBRD Third Highway Project will begin in 1985. Over a four year period the project will strengthen RBPC through:

(1) technical assistance and training in management and organization and planning and execution of road maintenance; (2) provision of equipment spares and limited supplies of fuel and bitumen; and (3) consultancy services for a highway organization and investment study.

It is recommended that the construction of project feeder roads not involve RBPC due to their present and programmed construction and maintenance responsibilities plus the training program. Because of the existing RBPC maintenance installation at Dilling, it is recommended that the rehabilitation of the Kadugli to Dubiebat road be by RBPC.

3. By American Contractor

Construction of the 455.6 km of feeder roads are divided into four packages with the first package construction programmed to begin in 1987. A new package will commence in each of next three years. Length of roads in a package vary from a low of 80 km to a high of 145 km. Estimated financial cost of the packages vary from a low of LS 6.28 million to a high of LS 12.46 million or US$ 3.0 million and US$5.9 million respectively at an exchange rate of LS 2.10.

Since financing of the road construction will be by CIP funds, payment will be in Sudanese pounds. It is therefore doubtful that an American contractor would be interested in the project. The relatively low monetary value of the project (as compared to the Kosti-El Obeid road) spread over a total of 5 years may make it more unattractive.

4. By American-Sudanese Joint Venture

It is difficult to discover any benefit from such a joint venture that would overcome the apparent disadvantages of an American contractor only operation. It is probable that the only work item an American contractor would desire to joint-venture would be masonry and pipe culvert construction by the Sudanese contractor.

5. By Sudanese Contractor

Listed in Table D-1 are the names and a brief summary of nine Sudanese construction firms. Seven are 100 percent Sudanese owned and the remaining two 60 and 65 percent foreign ownership. Since 1959 all highway construction has been by RBPC and/or foreign contractors. The local contractors earthwork experience has been principally subcontract haulage, some route clearance and embankment for the railroad, small roads and development embankments.

Inasmuch as most public road construction is by foreign financing with built-in restrictions, Sudanese contractors are unlikely to do road construction except by subcontract. The use of CIP funding is an opportunity to initiate Sudanese road construction capabilities. Perhaps it is significant that the project is feeder road construction oriented to rural communities and through labor intensification, increased community participation and involvement in the construction and maintenance activities. The use of local contractors is appropriate and recommended.

6. Contracting Procedures

All Sudanese contractors are familiar with and have performed work on a contractural basis, but none have had a contract with RBPC for road or bridge construction. Many contracts in Sudan are negotiated. For example, an outline drawing of a building may be given to one or more contractors who will study the drawing and return with a detailed proposal to the client. He will select (not necessarily the least cost proposal) and then negotiate with the selected contractor a final contractural arrangement.

In general, Sudanese contractors are not experienced in the construction of engineered roads and/or bidding on a detailed bill of quantities for road construction. As defined in the PID, one of the goals or objectives of this project is to establish in Sudan capabilities for road construction by local contractors. This is not a simple task and will involve not only assistance to them in construction techniques, and equipment management and maintenance, but also preparation of tenders for road construction.

Table D-1

BRIEF SUMMARY OF SUDANESE CONTRACTORS

Contractor	Percent Sudanese Ownership	Major Equipment Owned: Dozers	Graders	Loaders	Tipper Trucks	Rollers	Year Organ.
. Hussein Musa's Enterprises	100	7	6	9	36	4	1981
. Sayed Enterprises	100	10	-	2	-	2	1958
. Africa Construction	100	8	2	9	-	2	1978
. Factory Equipment	100	-	4	2	6	1	1968
. Commandite International	100	4	1	3	17	1	1981
. Soba Engineering & Trans.Co.	100	-	1	2	10	4	1981
. Harbor Services, Trading & Engineering							
. Sudanese Korean Const.Co.	35	2	2	3	15	4	1982
. Sixco Limited	40	1	1	9	12	-	1977

Contractors	Remarks
. Hussein Musa's Enterprises	Has done more earthworks than other contractors, including 2 million m^3 for RBPC and Chevron. Primary activity is earthworks and hiring his equipment to others.
. Sayed Enterprises	In addition to stone quarry operations, main activities is route clearance and embankments for railroads, building earch dikes for ponds and canal excavation.
. Africa Construction	Primarily engaged in building construction.
. Factory Equipment	Specialize in steel fabrication but have diversified to pipe line track maint.
. Commandite International	Worked as sub-contractor for Chevron on earthmoving and warehouse construction.
. Soba Engineering & Transport Co.	Worked as sub-contractor on several small roads and other earthwork projects.
. Harbor Services, Trading & Engin.	Works only in Port Sudan area. Has done several roads and earthfills.
. Sudanese Korean Const. Co.	Since organization, work has been primarily construction and paving streets in Omdurman. All key engineering staff are Korean.
. Sixco Ltd.	Firm is presently engaged in building construction, but plans to diversify into road construction.

To establish acceptable tendering techniques and to insure the contractor is fully aware of the work involved, it is recommended that competitive negotiated contracting procedures be used. This could be accomplished as follows:

1. Early in the project Sudanese contractors would be requested to furnish certain selected information concerning their company as a prequalification step.

2. Prequalification material would be evaluated by GOS and the Consultant, and the contractors ranked according to the evaluation results.

3. For the first roads to be constructed (Phase 1) proposals would be requested from say the three highest ranked firms. The proposals would include, but not necessarily be limited to, their estimated unit prices and costs for the various items of work, equipment that they need to acquire, a re-statement of equipment on hand, and a list and experience resume of key staff including senior foremen, master mechanics, and surveyors.

4. Proposals would be evaluated and ranked by GOS and the Consultant. The proposal ranked highest may not be the lowest in cost because of lack of personnel or unrealistic unit prices. The selected contractor would be called in and prices exceeding established limitations (both high and low) negotiated based upon a detailed estimating procedure.

5. Beginning with Step 2 and at each subsequent step, unsuccessful contractors would be informed and explained in detail the reason(s) for their low ranking and recommendations made to them so they might be considered for subsequent phases. It is possible that the financial capabilities of contractors successful in early stages of the project will be exceeded.

6. Upon completion of the competitive negotiations, the details with supporting data will be submitted to USAID for their review and approval.

7. In the event negotiations are not successful with the higher ranked contractor, negotiations will be conducted with the second ranked contractor.

It may be possible by Phase 3 (nine construction contracts will have been negotiated) that normal tendering procedures can be adopted, with tenders being rejected for such standard reasons as over-extended financial capabilities, insufficient equipment and supervisory personnel, or an unbalanced tender.

The evaluating process of both contractors' qualifications and tenders followed by administrative monitoring of the contracts is not a small task. It is therefore recommended that the technical assistance Team Director be stationed in Khartoum so these tasks.

Program of Construction Contracts

In keeping with the recommendation to use Sudanese contractors, the size of contracts were adjusted downwards from large contracts normally associated with foreign contracts. Tabulated in Table D-2 are the recommended division of roads into separate contracts and the grouping of the contracts into construction phases. The average 1985 cost value of a contract is LS 28 million, with an average length of 28 km. Table D-3 gives the timing of each package. The construction schedule calls for construction to begin September 1986 on Phase 1, Kadugli-Talodi Road, and for completion of construction on Phase 4 in December 1991. Each contract's construction period includes four months for mobilization.

The selection of the Kadugli-Talodi Road for the first package was not based upon the economic analysis results, but upon its proximity to the rehabilitation work on the Kadugli-Dilling-Dubiebat Road which is scheduled to commence August 1986. It is desirable for project management and implementation that early field activities to be concentrated in one general area with the dispersal of activities occuring later in the project life.

Table D-4 gives the number of contracts in progress each year of the construction period and the estimated yearly expenditures based upon 1985 costs. These yearly expenditures have been escalated using a 13 percent annual escalation rate. Total estimated construction costs increase from a 1985 cost of LS 36.8 million to an excalated cost of LS 47.4 million. Because of high proportional cost that earthworks represents to contract total costs, the expenditure schedule is based upon 60 percent of a contract being completed in the first year of construction.

Table D-2

PROPOSED PROGRAMING OF CONSTRUCTION CONTRACTS

Road Section	Length (Km)	Est. Cost (1000LS)	Number of Contracts	Average Cost (LS 1000)	Average Length (Km)
a. Kadugli - Talodi	91.6	7,090	3	2,363	31
b. El Abbasiya - Barid	23	2,210	1	2,210	23
c. Barid - Sherkeila	50	4,500	2	2,250	25
d. Sherkeila - Balahat	12	1,050	1	1,050	12
e. Rashad - El Abbasiya	60	4,700	2	2,350	30
Subtotals	145	12,460	6	2,077	24
f. Talodi - Shagrabeh	53	4,160	2	2,080	27
g. Shagrabeh - Kalogi	27	2,120	1	2,120	27
Subtotals	80	6,280	3	2,098	27
h. Kalogi - Abu Gubeiha	83	6,980	2	3,490	42
i. Abu Gubeiha - Rashad	56	3,990	2	1,995	28
Subtotals	139	10,970	4	2,743	35
TOTALS	455.6	36,800	16	2,300	28

Table D-3

CONSTRUCTION SCHEDULE & OPENING OF ROADS

Phase	Road	Length km	Construction Period(1)	Opening Date
1	Kadugli-Talodi	91.6	Aug 86 - Dec 88	Jan 89
2	El Abbasiya-Balahat Rashad-El Abbasiya	85 60	Aug 87 - Dec 89	Jan 90
3	Talodi-Kologi	80	Aug 88 - Dec 90	Jan 91
4	Kalogi-Abu Gubeiha Abu Gubeiha-Rashad	83 56	Aug 89 - Dec 91	Jan 92

(1) Includes mobilization by contractor

Table D-4

YEARLY CONTRACT NUMBER AND EXPENDITURES

Year	Number of Contracts in Progress	Estimated Expenditure (1) (LS1000)	Escalated Expenditures(2) (LS1000)
1987	3	4,254	4,254
1988	9	10,312	11,653
1989	9	8,752	11,173
1990	7	9,094	13,122
1991	4	4,388	7,156
	Totals	36,800	47,360

(1) Based upon 60% of contract completed in first year, a two year construction period and costs not escalated.

(2) Estimated annual escalation rate of 13%.

Equipment, Fuel and Materials for Sudanese Contractors

Project construction cost estimates include equipment, fuel and material costs. In theory, it is the responsibility of the contractor to obtain all three. In Sudan, construction equipment, spare parts, fuels and certain materials such as reinforcing steel, and to a lessor extent lumber and cement, are imported. Due to importation procedures and foreign currency exchange controls, the local contractors have problems with importation and may have to pay premium prices in Sudanese pounds for items critical to their operations.

Only a cursory review of Sudanese contractors' equipment inventory was made. Even though some equipment is relatively new, it may not be operational because of the lack of spare parts.

Because of these unfavourable conditions, we recommend that means be provided for the timely import of needed items. During the competitive negotiation stage, a list of construction items for which importation and foreign currency is required can be prepared. Several methods of import implementation have been suggested, among which are: (1) making foreign currency available to contractor; (2) importation of the various items by USAID with reimbursement being made by the local contractor in Sudanese pounds. Reimbursement could be immediate or pro-rated over the life of the contract. In lieu of repayment for equipment, alternatives are lease-purchase or just leasing. Maintenance of equipment under each alternative must be insured.

It is recommended that the providing of assistance to the local contractors for importation of required construction equipment, spare parts, fuels and selected materials be approved in principle and the manner of implementation be determined in the early life of the project during evaluation and prequalification of local contractors.

Listed in Table D-5 is a list of major items of equipment needed for the construction of a typical 28 km long feeder road constructed to project standards. The foreign exchange requirement is US$ 1.7 million if all equipment is imported. This should not be the case. Table D-6 gives the estimated fuel and lubricant requirements. For cement and lumber only a provisional sum has been given based upon sums estimated for other projects, but scaled down for project's lower standards.

Table D-5

LIST OF MAJOR CONSTRUCTION EQUIPMENT FOR TYPICAL 28 KM FEEDER ROAD

	Item	No.	Unit Price	Amount
			(1000 US$)	
1.	Tipper Truck, $7m^3$	9	60	540
2.	Grader, 125 HP	2	110	220
3.	Loader, $1.0m^3$	2	70	140
4.	Farm Tractor w/trailer	4	35	140
5.	Towed Roller	2	20	40
6.	Towed Water Tank	2	15	30
7.	Dozer, D6	1	130	130
8.	Towed Fuel Tanker	1	20	20
9.	Service/Lub. Truck	1	40	40
10.	Pickup Truck, 3/4 ton	2	25	50
11.	Concrete Mixer, $o.4m^3$	4	5	20
12.	Generators, Welders, Pumps, Air Compressors, Concrete Vibrators etc.	-	60	60
13.	Hand Tools	-	20	20
	Subtotal			US$1,450
14.	Procurement Shipping:			
	US to Port Sudan (a)			250
	Port Sudan to job site			0 (b)
	TOTAL			US$1,700

(a) Cost of US origin equipment available from International depots will reflect shipping cost in quoted unit prices.

(b) By contractor.

Table D-6

ESTIMATED FUEL AND MATERIAL COSTS
FOR TYPICAL 28 KM FEEDER ROAD

	Item	Unit	Quantity	Unit Price (US$)	Amount
1.	Diesel Fuel	Imp.Gal	200,000	1.70	340,000
2.	Gasoline	Imp.Gal	20,000	2.80	56,000
3.	Oils/Lubricants(a)	-	-	-	20,000
4.	Cement	-	-	-	30,000
5.	Lumber	-	-	-	10,000
	Total Estimated Cost (b)				US$456,000

(a) Estimated at 5 percent of fuel costs

(b) Shipping is not included since origin is not known.

E. Rehabilitation of the Kadugli-Dubeibat Road

1. Description

This 186 km road links Kadugli the capital of Southern Kordofan with the railroad station at Dubeibat. Construction was completed by RBPC in May 1976, using a force account system, with construction extending over a five year period. The road has a 7m wide DBST surface except for a 50 km long section extending south from Dilling which has only a single surface treatment. The reported base course is aggregate blended with sand. The average haul distance of the base material for the segment between Kadugli and Dilling was 7 km and more than 20 km for the road north of Dilling.

2. Existing Condition

The road's surfacing is badly deteriorated from lack of both routine and periodic maintenance. Some segments of the road were opened to traffic over 10 years ago. Since completion, only occasional surface maintenance has been performed, consisting of pot hole repair whenever asphalt is available. It is estimated that from approximately 5 to 10% of the road must have complete base course reconstruction prior to any resurfacing. Substantial sections of shoulders will need rehabilitation. The RBPC maintenance section located at Dilling rehabilitate shoulders whenever fuel is available for equipment. Tabulated in Table E-1 are routine and periodic maintenance funds requested by the RBPC and the amounts actually allocated.

3. Relationship to Project Roads

North of Dubeibat, a new gravel surfaced road extends 94 km to El Obeid the capital of Kordofan Region. Starting in 1985, the road is to be upgraded to a paved road with base course and DBST pavement. The construction of a 301 km paved road from El Obeid to Kosti via En Rahad and Umm Ruwaba is scheduled to start in 1986. The relationship of the project feeder roads extending from Kadugli to Umm Ruwaba is clearly illustrated on Figure A-1.

Because of the dependance of the western portion of the feeder roads on the Kadugli-Dubeibat Road, it is essential that this road artery be maintained in a passable condition. If rehabilitation is not accomplished within the next 2 to 3 years the rate of deterioration will accelerate.

Table E-1

ROUTINE MAINTENANCE FUNDS FOR
KADUGLI-DILLING-DUBEIBAT ROAD
(Sudanese Pounds)

	Funds Requested		Funds Allocated	
Fiscal Year	Amount	Per Km	Amount	Per Km
1979/80	241,000	1,296	41,000	220
1980/81	396,000	2,129	193,000	1,038
1981/82	441,000	2,371	366,000(1)	1,075
1982/83	837,000	4,500	49,000	263
1983/84	1,191,000	6,403	57,000	306
1984/85	724,000(2)	5,323	80,000(3)	430

Source: RBPC
(1) Includes Ls.170,000 used for construction of 2 bridges, 6 box culverts and rip rap.
(2) For only 136 km. Maintenance fund for remaining 50 km included in requested periodic funds.

Breakdown of 1984/85 Requested Funds

1. Salaries, wages and allowances for staff	Ls.23,480
2. Salaries, wages and allowances for labor	244,780
3. Plant hire, spare parts & fuel	425,840
4. Maintenance of road camps	30,000
Total	Ls.724,000

(3) Approved by Ministry of Finance but not yet given to RBPC. RBPC informed Sept. 9, 1984 that only Ls.300,000 had been allocated for all paved roads.

PERIODIC MAINTENANCE FUNDS
KADUGLI-DILLING-DUBEIBAT ROAD
(Sudanese Pounds)

	Funds Requested(1)		Funds Allocated	
Fiscal Year	Amount	Per Km	Amount	Per
1981/82	2,390,000	12,850	Nil	Nil
1982/83	3,896,000	20,950	"	"
1983/84	5,895,000	31,690	"	"
1984/85	9,156,000	43,850	"	"

Source: RBPC
(1) For base repair and asphaltic overlay.

4, Recommendation

It is recommended that the rehabilitation of the Kadugli-Dubaibat Road be done by RBPC's maintenance group located at Dilling, and that financial assistance needed for purchase of additional equipment, asphalt, fuel and other materials be included in this project.

5. Estimated Rehabilitation Costs

Listed in Table E-2 is the equipment required for the rehabilitation of the road. Some of the equipment listed is owned by RBPC and is presently located at Dilling. It is serviceable and could be used for the rehabilitation work, in particular shoulder rehabilitation. Since rehabilitation will not start until late 1986, it is not certain whether the equipment will still be serviceable and/or available. Nevertheless, the cost for these particular pieces of equipment have not been included and if not available either new or used but serviceable equipment would be furnished by GOS.

A summary of the costs in US dollars and Sudanese pounds for office and workshop equipment, spare parts, construction materials, fuel oil and lubricants, and procurement and shipping are tabulated in Table E-3.

Technical Assistance

As part of the technical assistance team, a Maintenance Engineer and Master Mechanic are recommended to be assigned at Dilling to assist RBPC in the rehabilitation of the road and maintenance of the equipment. Period of service, estimated to be a total of 20 months, would be two dry seasons and the intermediate wet season. Table E-5 gives the estimated cost for this technical assistance.

Table E-2

EQUIPMENT REQUIREMENTS FOR REHABILITATION OF KADUGLI-DUBEIBAT ROAD

Equipment(1)	No.	US$1,000
1. Tipper trucks, $7m^3$	10	600
2. Tipper trucks, $10m^3$	5(a)	-
3. Front end loaders, rubber tyred	2(b)	160
4. Grader	2(a)	-
5. Dozer	1(a)	-
6. Roller, steel wheel, SP	1	50
7. Roller, pneu. SP	1	50
8. Roller, pneu. towed	2	20
9. Farm tractors, towing	3	105
10. Truck, bitumen distributor	1	45
11. Pre-heater, bitumen	1	25
12. Secondary crusher, 50 TPH complete with screens	1	420
13. Water tanker truck	2	80
14. Fuel truck	1	75
15. Broom, towed	1	7
16. Chip spreader, SP	2	30
17. Pick up trucks 3/4 ton	2	50
18. Field service lub. truck	1	60
19. Trailers, fuel, towed	3	30
20. Jeep land cruiser	1	20
21. Trailer, water, towed	2	20
22. Flatbed truck	2	110
23. Generators, welders, air compressors, radio sets,etc.	Lot	70
24. Hand tools	Lot	20
Total		US$1,942

(a) Presently on hand at Dilling
(b) One front end load on hand at Dilling

Table E-4

SUMMARY OF EQUIPMENT, FUEL & MATERIALS, AND PROCUREMENT COSTS FOR REHABILITATION OF KADUGLI-DUBEIBAT ROAD

Items	1000 US$	1000 Ls.
A. Office & Workshop		
1. Office Equipment	10	2
2. Lab. Equipment	15	5
3. Shop Compound/Warehouse(a)	30	50
4. Tools for equipment repair	80	10
5. Logistical Support	-	50
Sub-total	135	117
B. Rehabilitation Equipment	1,942	-
C. Spare Parts		
For items in A&B including tyres and shipment	600	30
D. Construction Materials		
1. Bituminous products	2,600	390
2. Base course & chippings	-	100
E. Fuel/Oils/Lubricants	360	50
F. Procurement Shipping		
1. US to Port Sudan	260	-
2. Port Sudan to Dilling	-	160
G. Total Estimated Procurement Costs	FX$5,897	Ls.847
Use	FX$5,900	Ls.850

(a) Renovation of existing facilities

Table E-5

ESTIMATED TECHNICAL ASSISTANCE COSTS
REHABILITATION OF KADUGLI-DUBEIBAT ROAD

Item		1000 US$	1000 Ls.
1. Salaries (field overheads & post differential)			
a. Maintenance Engineer		251	79
b. Master Mechanic		238	75
2. Allowances: 40 months		90	
3. Travel, consumables, unaccompanies baggage, etc.		178	92
4. Fee @ 10% of item 1 less overhead		26	8
Sub-Total		783	254
USE	FX$	700	250

F. Implementation of Road Maintenance

1. General

A USAID publication "New Directions in Rural Roads" suggests accepting the reality that roads in most underdeveloped countries are not going to be maintained given present governmental infrastructure and funding realities. The problem of maintenance also applies equally to maintenance of the mechanized equipment. This is not an acceptable alternative since the result is the gradual and subsequent accelerated deterioration of roads and equipment.

In any developing economy where general labor productivity is low and a surplus of unskilled labor is abailable at low cost, the desirability of utilizing labor intensive methods and consequently the employment of more people rather than mechanized operations is questioned. Certain operations such as cleaning drainage ditches and structures, repair of pot holes, repairing embankment slope erosion, vegetation control and similar tasks lend themselves to the use of labor intensive methods. Other operations such as loading dump trucks, and shaping and compacting gravel surfacing can be done cheaper and easier using mechanized equipment.

One possible means of increasing the liklihood of maintenance operations actually being performed upon completion of construction might be a restriction in the use of mechanized equipment to only those items of work for which the need is obvious and to maximise the amount of local community labor. The use of local labor living along the particular section of road being built would create from the start identification of each portion of the road with the communities it serves. It would also result in the training of members of the community in road construction tasks. This policy may create some inconveniences such as s reduction in the speed of construction and a possible increase in turnover of personnel. The latter could be caused by interference of agricultural labor needs and the supply of people to the maintenance groups as construction of segments of road are completed and maintenance operations commence.

1. Basic Routine Maintenance

In the determination of estimated annual basic routine maintenance costs, we estimated that one basic maintenance crew can maintain slightly more than 12 kms of feeder road based upon 243 working days per year and working hours from 7am to 2pm. Working days were determined as follows:

ESTIMATE OF WORKING DAYS PER YEAR

	Item	Days per Year	
1.	Total days per year		365
2.	Fridays	52	
3.	Leave	15	
4.	Holidays	15	
	Subtotal	82	82
5.	Balance of days in year		283
6.	Sickness	12	
7.	Rain	28	
	Subtotal	40	40
8.	Net Working Days per Year		243

A typical basic maintenance crew is as follows:

	Item	No.
1.	Foreman	1
2.	Driver	1
3.	Laborers	10
4.	Pickup Truck	1
5.	Hand Tools	as required

For the 91.6 km long Kadugli - Talodi Road, six crews each maintaining 15.3 kms would be required. Obviously the need for six pickups is questionable. A more reasonable arrangement would be six crews each supervised by a head-laborer and a foreman with pickup truck supervising two crews. Using this refined organization, the basic routine maintenance requirements are shown in Table F-1 for each road section (number of km maintained by a crew adjusted to fit road lengths).

Table F-1

PERSONNEL AND EQUIPMENT REQUIREMENTS
BASIC ROUTINE MAINTENANCE

Road Section	No. of Crews	Foremen	Pickup Trucks(1)	Head Laborers	Laborers
1. Kadugli-Talodi	6	3	3	6	60
2. Talodi-Kologi	5	3	3	5	50
3. Kalogi-Abu Gubeiha	6	3	3	6	60
4. Abu Gubeiha-Rashad	4	2	2	4	40
5. Rashad-El Abbasiya	4	2	2	4	40
6. El Abbasiya-Balahad	6	3	3	6	60
Totals	31	16	16	31	310

(1) Includes driver.

Crews, tools and pickup trucks for a road will be needed approximately three months prior to completion of construction for organization and training.

3. Variable Routine Maintenance

For the determination of costs for the periodic grading and compaction of in-place gravel surfaces, we estimated that one brigade could complete 3km per 7 hour day and that an average of two passes were required each year. The proposed equipment and staffing of a brigade is shown in Table F-2.

Table F-2

PERSONNEL AND EQUIPMENT REQUIREMENT
VARIABLE ROUTINE MAINTENANCE

	Item	No.
1.	Grader	1
2.	Tractor w/trailer	2
3.	Towed Roller	1
4.	Water Tank, towed	1
5.	Pickup Truck	1
6.	Misc. Hand Tools	as required

Table F-2 (contd)

	Item	No.
8.	Operators	3
9.	Drivers	1
10.	Laborers	10

Based upon 243 working days per year, a rate of 0.50km per hour, two passes per year and 20 percent down-time for maintenance and repair of equipment (for example when grader needs repair there is a work stoppage) one brigade can maintain about 290 km per year. Based upon this annual rate, equipment for the first brigade will be required by the opening year of Phase I and for a second brigade shortly before completion of Phase 3.

4. Periodic Maintenance

Periodic maintenance is the replenishment, grading and compaction of the gravel surface. For determining maintenance costs, we estimated that the equipment and staffing tabulated in Table F-3 would be required.

Table F-3

PERSONNEL AND EQUIPMENT REQUIREMENT
PERIODIC MAINTENANCE

	Item	No.
1.	Tipper Truck $7m^3$	5
2.	Front End Loader	1
3.	Grader	1
4.	Tractor w/trailer	3
5.	Towed Roller	1
6.	Water Trailer, towed	2
7.	Pickup Truck	1
8.	Foreman	1
9.	Operators	5
10.	Drivers	6
11.	Laborers	10
12.	Misc. Tools	as required

Based upon a gravel replacement every 4 to 5 years of $275m^3$, an average haul distance of 15 km, truck loading time, a 6 hour day, 243 working days, and a 20 percent time loss for equipment meintenance and repair, one brigade can maintain about 120 km annually. One brigade can therefore regravel the 455.6 km of project roads every 4 years.

SUMMARY OF EQUIPMENT AND PERSONNEL REQUIREMENTS
FOR BASIC AND VARIABLE ROUTINE ROAD MAINTENANCE

ase	Road Section	Km	Opening Year(1)	Pickup Trucks	Graders	Tractor w/ trailer	Towed Rollers	Water Tanks	Foremen	Labor-ers(2)	Oper-ators	Drivers
1	Kadugli-Talodi	91.6	1989	4	1	2	1	1	4	76	3	4
2	El Abbasiya-Balahat	85	1990	3	-	-	-	-	3	66	-	3
2	Rashad-El Abbasiya	60	1990	2	-	-	-	-	2	44	-	2
3	Talodi-Kologi	80	1991	3	-	-	-	-	3	55	-	3
3	Kologi-Abu Gubeiha	83	199	4	1	2	1	1	4	76	3	4
4	Abu Gubeiha-Rashad	56	1992	2	-	-	-	-	2	44	-	2
		455.6		18	2	4	2	2	18	361	6	18

(1) Approximate time equipment and personnel needed on site

(2) Includes Head-Laborers.

5. Implementation

The Roads and Public Bridges Corporation (RBPC) is responsible for construction of all roads, and maintains paved roads and bridges. The maintenance of earth and gravel roads is the responsibility of the regional governments with technical assistance provided by RBPC regional managers. RBPC's organizational structure has too many layers of management while the maintenance division suffers from inadequate staffing. The IBRD's Highway Organization and Investment Study is to define RBPC's future functions and recommend improvements to its organization. Agreement has been reached between IBRD and GOS that not later than June 30, 1987 a plan will be implemented to improve the organization of RBPC.

RBPC maintains the paved roads and bridges through regional managers. Each region is divided into two or more districts supervised by district engineers. Road maintenance has suffered through lack of adequately trained staff and low availability of equipment. Although the equipment fleet is nominally adequate, many items have become unserviceable due to lack of proper maintenance. Equipment availability is low because of ill-trained mechanics, poor workshop organization and management, and an insufficient supply of spare parts (this is probably compounded by diversity of equipment originating from various foreign Governments giving equipment aid). The IBRD Third Highway Project will provide for technical assistance to improve workshop operations including training, the procurement of spare parts and components for equipment rehabilitation, and the implementation of training and road maintenance programs. The IBRD Project target date for completion is June 30, 1988. (1)

The dates by year when maintenance operations must commence on each of the project road sections is shown in Table F-5. RBPC's organizational changes and training program will be completed prior to the earliest commencement year.

Table F-5

SCHEDULE OF MAINTENANCE IMPLEMENTATION

Package	Road	Length Km	Accum. Length Km	Year Maintenance Starts Routine	Periodic (a)
1	Kadugli-Talodi	91.6	91.6	1989	1992
2	El Abbasiya-Balahat	85	176.6	1990	1993
	Rashad-El Abbasiya	60	236.6	1990	1993
3	Talodi-Kologi	80	316.6	1991	1994
	Kologi-Abu Gubeiha	83	399.6	1991	1994
4	Abu Gubeiha-Rashad	56	455.6	1992	1995

(a) Shown one year early to insure maintenance group is organized and mobilized on time.

(1) Preceeding two paragraphs are excerpts from IBRD Third Highway Project Paper, February 28, 1984.

The Norconsult Report suggested four alternative organizational structures, each having a maintenance section. Alternate 1 shown on Figure F-1 has a centralized organizational structure more or less similar to today's structure for maintenance of primary roads.

Alternate 2 shown on Figure F-2 is a decentralized agency with centralized funding. The policy, establishing standards, control of efficiency, training of personnel, purchase of major equipment (may be used by more than one region), letting of major contracts would be the responsibility of RBPC. The Local Government (possibly Area Councils) would act as an agent for RBPC in carrying out the maintenance of feeder roads. The full responsibility however still rests with RBPC.

Alternate 3 is decentralized but with RBPC providing policy and uniformity of standards. Budget allocations and overall financial control are the responsibility of the Regional Government through a Regional Roads Department. Maintenance is the full responsibility of the Regional Government. Alternate 3 is shown on Figure F-3.

Alternate 4 is the most decentralized of the four with no connection to RBPC.

Norconsult recommended Alternate 3 since the organization was both technically acceptable and consistent with Government's stated decentralization policy. It was also considered appropriate for feeder road maintenance.

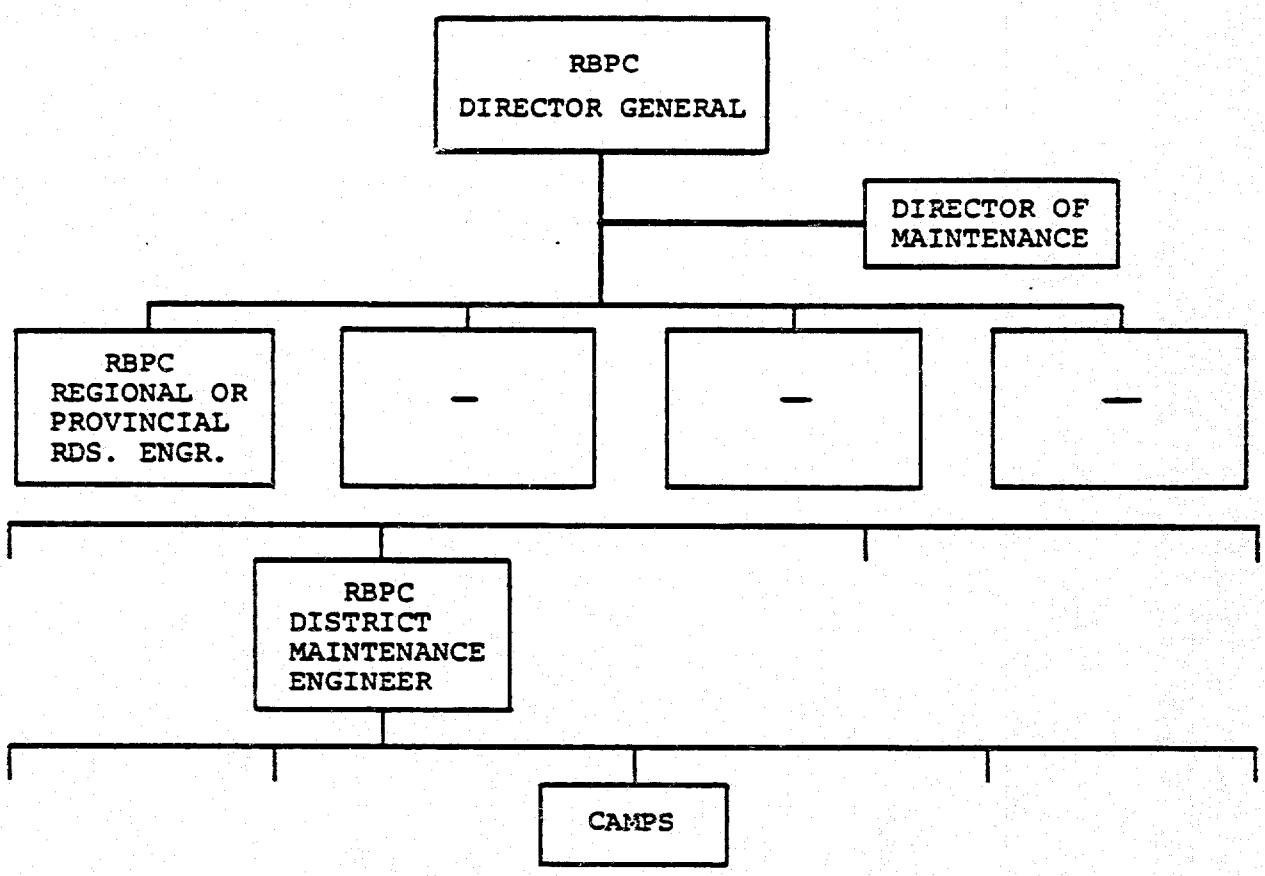
There is no certainty as to what organizational structure may result from the IBRD Third Highway Project nor changes that might be made by GOS for other reasons. Since it is the current policy that the maintenance of earth and gravel feeder roads as planned by the project are presently the responsibility of the Regional Government, it seems appropriate that implementation should be structured to conform to that policy.

Basic routine maintenance is the cleaning and minor repair of drainage ditches and structures, clearing vegetation, erosion control, and repairing pot holes. All work is by laborers and as such laborers should live close to the segment of road for which they are responsible. Since this maintenance is community oriented, one solution is for the responsible agency to contract with individual communities or villages to perform the basic routine maintenance on a specified segment of the road with tools, equipment and any materials whose source is outside the community being furnished by Government. This arrangement is adaptable to most any organizational structure that is finally selected. Periodic inspections by a representative of the responsible agency should be made to insure maintenance conformity.

Similarly, variable routine and periodic maintenance brigades can be administered by most organizational structures - centralized or otherwise. Due to the uncertainty of RBPC's and/or Regional Government's role, it is suggested that the administering agency who will

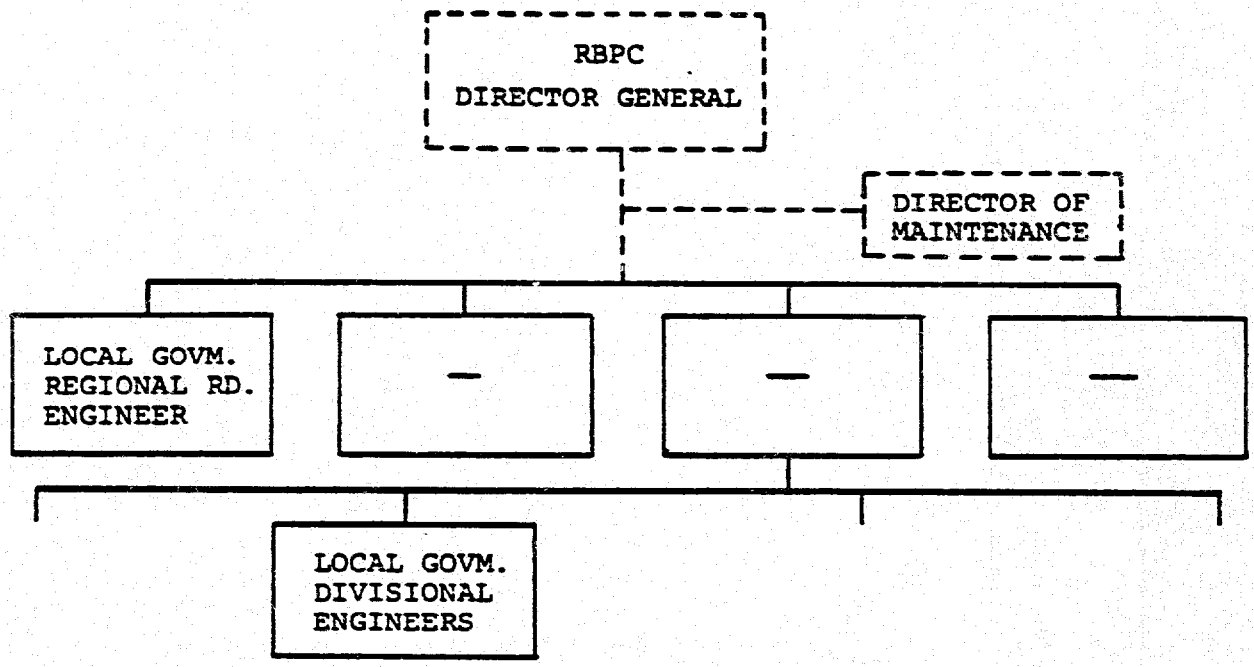
be responsible for administering and possibly organizing these maintenance efforts be determined and agreed with GOS during the second year of the project. If uncertainty still exists at that time, one solution is to extend the construction contractors contract to include the variable routine maintenance for a period of from one to two years.

Since the concept of basic routine maintenance being done on a community level basis with payment being made for that work effort will be a new concept to Sudan, problems in organizing and administering it will occur. Even though some of the laborers may have worked on the road construction, additional instruction in proper maintenance procedure will be required. Possible assistance by the Peace Corps seems desirable and should be investigated.



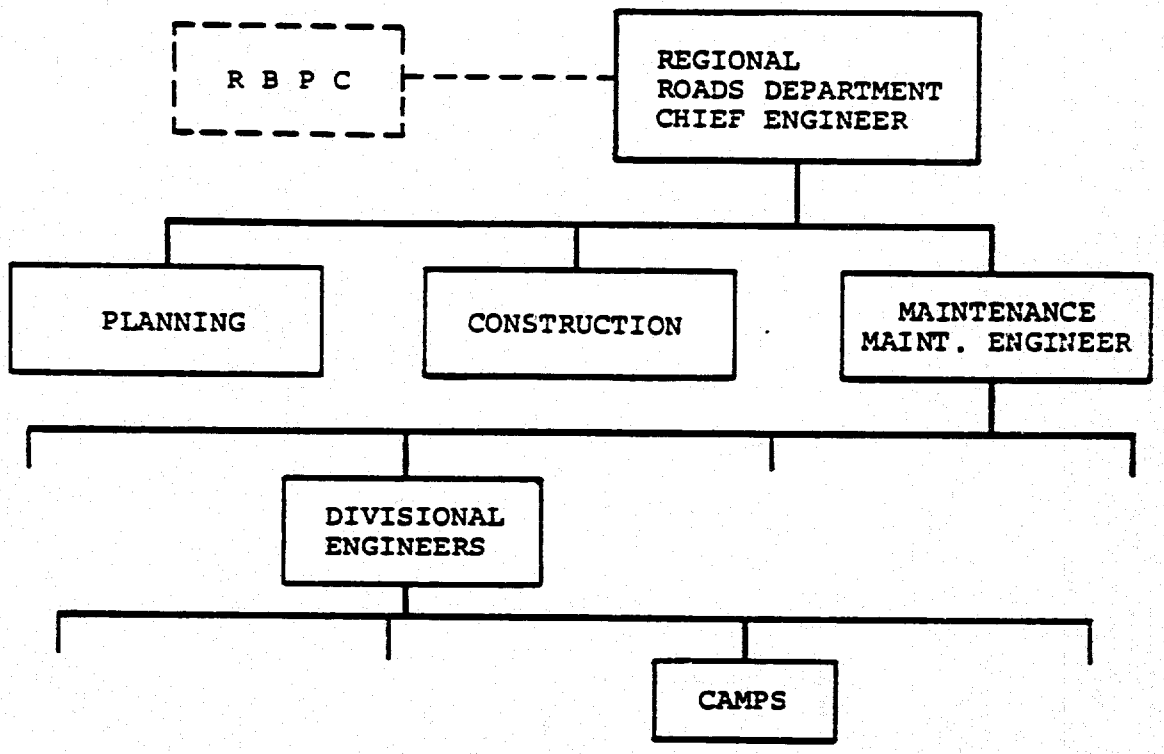
MAINTENANCE ALTERNATE 1-CENTRALIZED

FIGURE F-1



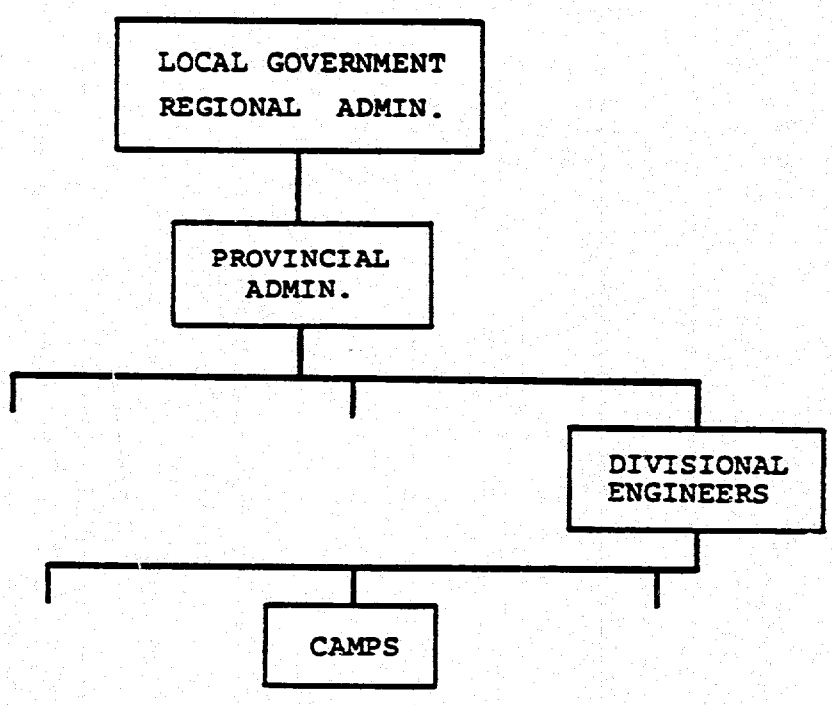
MAINTENANCE ALTERNATE 2 -DECENTRALIZED
AGENCY WITH CENTRALIZED FUNDING

FIGURE F-2



MAINTENANCE ALTERNATE 3-DECENTRALIZED
RBPC PROVIDE POLICY AND UNIFORMITY IN STANDARDS

FIGURE F-3



MAINTENANCE ALTERNATE 4-DECENTRALIZED
NO CONNECTION TO RBPC

FIGURE F-4

G. Technical Assistance Requirements

1. Design Stage

Because of the remoteness of the project area, the lack of accurate and/or large scale mapping,and soils survey data, the cost of detailed field surveys and final design plans would be practically the same as those prepared for higher standard roads. For project's low cost roads, we consider the need for detailed plans normally expected and prepared prior to construction to be unnecessary.

The existing tracks for most project roads are not well defined and as a result there will be considerable latitude in the establishment of final alignments. Because most of the area is relatively flat, most of the road formation will be fill rather than a cut section. Problems with horizontal curvature should not occur and design of the vertical alignment will be relatively simple.

We therefore propose that standard drawings of pipe, box and open-bottom culverts, fords, ditches, erosion control measures and other similar details be prepared during the first stage of the project. The standards would be detailed for multiple applications, but because of the terrain the number of different applications will not be significant.

While standard details are being prepared, the alignments for Phase 1 roads (see Construction Implementation) will be established in the field, major topographic features noted and a surveyed centre-line profile of existing ground obtained. Additional profiles at major stream crossing may also be taken.

During the design of Phase 1 the Soils Engineer will locate sources of supply for select material, pit-run gravel, laterites, and sand and gravel. These will be established for all the project roads during the Soils Engineer's contemplated single assignment.

The Drainage Engineer will establish for all major streams drainage areas and runoffs, using available mapping and agriculture aerial photos. Using the stream corss-sections, high water marks from observation and discussion with local people, and flowline gradients, stream flow quantities will be determined for the remaining definable water courses. Because more than 170 water courses were noted during our field reconaissance, it is probable that all stream flows will not be established during the Drainage Engineer's proposed single assignment. He will, however, establish the procedures and methodologies so that resident staff can complete the drainage designs for the other phases.

Line drawings showing horizontal and vertical designs, standard detail drawings and bill of quantities of construction items will form the design input to the contract documents for the competitive negotiations. Exact positioning of pipe, box and open-bottom culverts and fords will be established during construction. It is probable that minor changes to vertical alignments will be required as drainage flow line are finalized and as a consequence road profile adjusted to fit the drainage structure.

The design of subsequent phases will continue in a similar manner (with refinement made as appropriate) for the life of the project. As a result design costs will be low in keeping with the standard of roads. Because most design features will be determined and/or finalized on site, the resultant product should conform closely to local needs and conditions. Table G-1 lists the staffing requirements for the Design Stage.

Table G-1

Design Stage Staffing

Staff	Trips(a)	Man-Months
Foreign Consultant		
1. Highway Design Engineer	4	24
2. Drainage Engineer	1	6
3. Soils Engineer	1	6
4. Engineer (field unspecified)	1	4
Totals	7	40
Local Consultant		
1. Location Engineer	4	24
2. Drainage Engineer	1	6
3. Structural Engineer	1	6
4. Soils Engineer	1	6
5. Sr. Surveyor	4	20
6. Surveyor	4	20
Totals	15	82

(a) Number of trips for foreign staff and number of times assigned to design group for local staff.

2. Construction Stage

The award of construction contracts for Phase 1 roads is scheduled for August 1986. The contractors will be given four months for mobilization on site with actual construction beginning in January 1987. The scheduling of construction contracts is given in Table G-2.

Table G-2

Project Construction Schedule

Phase	Road	Road Length (km)	Construction Period(1)	Number of Contracts
1	Kadugli-Talodi	91.6	Aug 86 - Dec. 88	3
2	El Abbasiya-Balahat	85	Aug 87 - Dec. 89	4
	Rashad-Al Abbasiya	60	Aug 87 - Dec. 89	2
3	Talodi-Kalogi	80	Aug 88 - Dec. 90	3
4	Kalogi-Abu Gubeiha	83	Aug 89 - Dec. 91	2
	Abu Gubeiha-Rashad	56	Aug 89 - Dec. 91	2
	Totals	455.6		16

(1) Includes a 4-month mobilization period.

Sudanese contractors are not experienced in the construction of engineered roads nor preparing a tender based upon a detailed bill of quantities for road construction. As defined in the PID, one of the goals or objectives of this project is to establish in Sudan capabilities for road construction by local contractors. This is not a simple task and will involve not only assistance to them in preparing tenders, but also in road construction techniques and management and maintenance of equipment. The construction is therefore basically a construction-management project and as such the consultant's staffing requirements must be increased to include personnel experienced in labor and equipment managment plus equipment maintenance. Listed in Table G-3 are the foreign staffing requirements for the Construction Stage. The local staffing is given in Table G-4. Local staffing requirements change annually, since in 1987 there will be 3 construction contracts in progress, 9 in both 1988 and 1989, 7 in 1990, and 4 in 1991.

Table G-3

Foreign Consultant's Construction Stage Staffing

Staff	Period	Man-Months
1. Resident Engineer	Nov 1986 to Jan 1992	63
2. Asst. Resident Engr.	Jan 1987 to Dec 1991	60
3. Const. Superintendant	Nov 1986 to Dec 1991	62
4. Quantity Surveyor	Jan 1987 to Dec 1991	60
5. Master Mechanic	Nov 1986 to Dec 1991	62
6. Maintenance Engr	Nov 1988 to Dec 1991	38
Total Man-Months		345

Table G-4

Local Consultant's Construction Stage Staffing

	Man - Months				
Staff(a)	Phase 1	Phase 2	Phase 3	Phase 4	Total
Senior Engineer (1)	26	12	12	13	63
Engineers (16)	72	144	72	96	384
Materials/Lab.Engr(2)	26	24	24	24	98
Quantity Surveyor(1)	26	12	12	13	63
Chief Inspector(2)	26	24	24	24	98
Inspectors(32)	144	288	144	192	768
Surveyors(2)	26	24	24	24	98
Senior Clerks(1)	26	12	12	13	63
Clerks(4)	48	48	48	48	192
Typists(2)	52	24	24	26	126
Totals	472	612	396	473	1953

(a) Number required during life of projects. Some staff not continually used for entire period.

3. Rehabilitation of Kadugli-Dubeibat Road

As part of the technical assistance team, a Maintenance Engineer and Master Mechanic will be assigned at Dilling to assist and advise RPBC in the rehabilitation of the road and maintenance of the equipment. Rehabilitation will start at the end of the rainy season in 1986 or about October. It is estimated that all the rehabilitation work can be completed in two dry seasons.

The Maintenance Engineer's and Master Mechanic's assignment in Dilling will begin in September 1986 and continue until April 1988 for a total of 20 man-months each.

4. Management

Pre-construction activities such as prequalification procedures for potential Sudanese contractors, finalising the list, advertising and ordering equipment, materials and fuels for rehabilitation of Kadugli-Dubeibat Road, designs of Phase 1 roads, preparation of contract documents, requests for and evaluation of proposals from local contractors and contract negotiations will consume a considerable portion of the project time period. Throughout this stage of the work, the T.A. Team Manager must be located in Khartoum.

The construction contracting procedure as outlined in Construction Implementation will occur annually for the following three years for Phases 2, 3 and 4. In addition to the work required by that task, the Team Manager will assist and advise RBPC on the administration of the 16 construction contracts. This cannot be accomplished out-station from Khartoum. Listed in Table G-5 are staff requirements for the consulting engineer's management office in Khartoum.

Table G-5

Staffing for Consulting Engineer's Management Office

Staff	Number	Total Man-Months
1. Team Manager (A&E)	1	80
2. Deputy Team Manager (local)	1	80
3. Senior Clerk (local)	1	80
4. Clerks (local)	2	150
5. Typists (local)	2	150

5. Cost Analysis of Engineering Services

1) Team Director (Sept. 85-April 92) - 80 months
(family status, 2 children)

a)	Salary (uninflated)	$4250 month
b)	Post differential (25%)	$1060 month
c)	Fringe (22%)	$ 990 month
		$6300 month
d)	Field overhead (85%)	$5350 month
		$11650 month

Escalation of overhead and incremental salary increases (10% per annum

		FX	LS (15%)
1985 :	4 months @ 11,650	46,600	6,990
1986 :	12 months @ 12,815	153,780	23,067
1987 :	12 months @ 14,096.5	169,158	25,374
1988 :	12 months @ 15,506	186,072	27,911
1989 :	12 months @ 17,057	204,684	30,703
1990 :	12 months @ 18,762	225,144	33,772
1991 :	12 months @ 20,638	247,656	37,148
1992 :	4 months @ 22,702	272,424	40,864
	FX$	1,505,518	LS$ 225,829

Allowances

- Education	(6.5 years @ 20,000)	$130,000
- COLA	(80 months @ $150)	12,000
- Misc. items	(6.7 years @ 1,000)	6,700
- Subtotal		148,700

Travel and Transportation

- Internal travel and per diem	-	LS$ 20,000
- Round trips @ $3,400 each 4 people x 6 trips x 3,400	81,600	12,240
- H.H. goods (3 times)	60,000	15,000
- Storage, unaccompanied baggage, consumables	90,000	13,500
- Subtotal	$231,000	$60,740
- Fee (10% of direct labor salary, post differential, fringe, escalations)	81,400	12,200
- Totals	FX$1,966,618	LS$ 298,769
- Use	FX$1,970,000	LS$ 300,000

2. Resident Engineer (Nov 86 - Jan 92) - 63 months
(family status, 2 children)

a)	Salary (uninflated)	$ 3,800 month
b)	Post differential (25%)	950 month
c)	Fringe (22%)	850 month
		5,600 month
d)	Field overhead (85%)	4,760 month
		$10,360 month

Escalation of overhead and incremental salary increases (10% per annum)

		FX	LS (15%)
1985 :	0 months @ 10,360	-	-
1986 :	2 months @ 11,396	22,792	3,419
1987 :	12 months @ 12,536	150,432	22,565
1988 :	12 months @ 13,789	165,468	24,820
1989 :	12 months @ 15,168	182,016	27,302
1990 :	12 months @ 16,685	200,220	30,033
1991 :	12 months @ 18,353	220,236	33,035
1992 :	1 month @ 20,189	20,189	3,028
		FX$ 961,353	LS$144,202

Allowances

- Education	(5 years @ 20,000)	100,000	-
- COLA	(63 months @ 150)	9,450	-
- Misc. items	(5 years @ 1,000)	5,000	-
		$114,450	-

Travel and Transportation

- Internal travel and per diem	-	6,000
- Round trips @ $3,400 each 4 people x 4 trips x $3,400	54,000	6,000
H.H. goods (2 times)	40,000	10,000
- Consumables, storage, unaccompanied baggage	60,000	10,000
	$154,000	LS$32,000
- Fee (10% of direct labor salary, differential, fringe, escalations	51,960	7,795
- Totals	FX$ 1,281,763	LS$ 183,997
Use	FX$ 1,280,000	LS$ 190,000

3. Assistant Resident Engineer (Jan 87 - Dec 91) - 60 months
(family status, 2 children)

a)	Salary (uninflated)	$ 3,400 month
b)	Post differential (25%)	850 month
c)	Fringe (22%)	750 month
		5,000 month
d)	Field overhead (85%)	4,250 month
		$ 9,250 month

Escalation of overhead and incremental salary increases (10% per annum)

		FX	LS (15%)
1985 :	0 months @ 9,250	-	-
1986 :	0 months @ 10,175	-	-
1987 :	12 months @ 11,192	134,304	20,146
1988 :	12 months @ 12,312	147,744	22,162
1989 :	12 months @ 13,543	162,516	24,377
1990 :	12 months @ 14,897	178,764	26,815
1991 :	12 months @ 16,387	196,644	29,497
		FX$819,972	LS$122,997

Allowance

- Education	(5 years @ 20,000)	100,000	-
- COLA	(60 months @ 150)	9,000	-
- Misc.items	(5 years @ 1,000)	5,000	-
		$114,000	-

Travel and Transportation

- Internal travel and per diem	-	6,000
- Round trips @ $3,400 each 4 people x 4 trips x $3,400	54,000	6,000
- H.H. goods (2 times)	40,000	10,000
- Consumables, storage, unaccompanied baggage	60,000	10,000
	$154,000	LS$32,000
- Fee (10% of direct labor salary, differential, fringe, escalations	44,323	6,648
- Totals	FX$1,132,295	LS$161,645
- Use	FX$1,130,000	LS$160,000

4. Maintenance Engineer (Nov 88 - Apr 92) - 42 months
(family status, 2 children)

a)	Salary (uninflated)	$ 3,800 month
b)	Post differential (25%)	950 month
c)	Fringe (22%)	850 month
		$ 5,600 month
d)	Field overhead (85%)	4,760 month
		$ 10,360 month

Escalation of overhead and incremental salary increases (10% per annum)

		FX	LS$(15%)
1985 :	0 months @ 10,360	-	-
1986 :	0 months @ 11,396	-	-
1987 :	0 months @ 12,536	-	-
1988 :	2 months @ 13,789	27,578	4,137
1989 :	12 months @ 15,168	182,016	27,302
1990 :	12 months @ 16,685	200,220	30,033
1991 :	12 months @ 18,353	220,236	33,035
1992 :	4 months @ 20,189	80,756	12,113
		$710,806	$106,620

Allowances

- Education	(3.5 years @ 20,000)	$ 70,000	-
- COLA	(42 months @ 150)	6,300	-
- Misc items	(3.5 years @ 1,000)	3,500	-
		$ 79,800	

Travel and transportation

- Internal travel and per diem	-	6,000
- Round trips @ $3,400 each 4 people x 4 trips x $3,400	54,000	6,000
- H.H. goods (2 times)	40,000	10,000
- Consumables, storage, unaccompanied baggage	60,000	10,000
	$154,000	LS$32,000
- Fee (10% of direct labor salary, differential, fringe escalations	38,422	5,763
- Totals	FX$ 983,028	LS$144,383
- Use	FX$ 990,000	LS$150,000

5. Construction Superintendent (Nov 86 - Dec 91) - 62 months
(family status, 2 children)

a)	Salary (uninflated)	$ 3,800 month
b)	Post differential (25%)	950 month
c)	Fringe (22%)	850 month
		$ 5,600 month
d)	Field overhead (85%)	4,760 month
		$ 10,360 month

Escalation of overhead and incremental salary increases (10% per annum)

		FX	LS(15%)
1985 :	0 months @ 10,360	-	-
1986 :	2 months @ 11,396	22,792	3,419
1987 :	12 months @ 12,536	150,432	32,565
1988 :	12 months @ 13,789	165,468	24,820
1989 :	12 months @ 15,618	182,016	27,302
1990 :	12 months @ 16,685	200,220	30,033
1991 :	12 months @ 18,353	220,236	33,035
1992 :	0 months @ 20,189	-	-
		$941,164	LS$141,174

Allowances

- Education	(5 years @ 20,000)	100,000	-
- COLA	(62 months @ 150)	9,300	-
- Misc items	(5 years @ 1,000)	5,000	-
		$114,300	-

Travel and Transportation

- Internal travel and per diem	-	6,000
- Round trips @ $3,400 each 4 people x 4 trips x $3,400	54,000	6,000
- H.H. goods (2 times)	40,000	10,000
- Consumables, storage, unaccompanied baggage	60,000	10,000
	$154,000	LS$32,000
- Fee (10% of direct labor salary, differential, fringe escalations	50,874	7,631
- Totals	FX$1,260,388	LS$180,805

6. Master Mechanic (Nov 86 - Dec 91) - 62 months
(family status, 2 children)

a)	Salary (uninflated)	$ 3,600 month
b)	Post differential (25%)	900 month
c)	Fringe (22%)	800 month
		5,300 month
d)	Field overhead (85%)	4,500 month
		$9,800 month

Escalation of overhead and incremental salary increases (10% per annum)

		FX	LS (15%)
1985 :	0 months @ 9,800	-	-
1986 :	2 months @ 10,780	21,560	3,234
1987 :	12 months @ 11,858	142,296	21,344
1988 :	12 months @ 13,044	156,528	23,479
1989 :	12 months @ 14,348	172,176	25,826
1990 :	12 months @ 15,783	189,396	28,409
1991 :	12 months @ 17,361	208,332	31,250
1992 :	0 month @ 19,097	-	-
		$890,288	$133,542

Allowances

- Education	(5 years @ 20,000)	100,000	-
- COLA	(62 months @ 150)	9,300	-
- Misc items	(5 years @ 1,000)	5,000	-
		114,300	-

Travel and Transportation

- Internal travel and per diem	-	6,000
- Round trips @ $3,400 each 4 people x 4 trips x $3,400	54,000	6,000
- H.H. goods (2 times)	40,000	10,000
- Consumables, storage, unaccompanied baggage	60,000	10,000
	154,000	32,000
- Fee (10% of direct labor salary, differential, fringe escalations	48,124	7,218
	FX$1,206,712	LS$172,760
- Use	FX$1,210,000	LS$170,000

7. Quantity Surveyor (Jan 87 - Dec 91) - 60 months
(family status, 2 children)

a)	Salary (uninflated)	$ 3,400 month
b)	Post differential (25%)	850 month
c)	Fringe (22%)	750 month
		5,000 month
d)	Field overhead (85%)	4,250 month
		$ 9,250 month

Escalation of overhead and incremental salary increases (10% per annum)

		FX	LS (15%)
1985 :	0 months @ 9,250	-	-
1986 :	0 months @ 10,175	-	-
1987 :	12 months @ 11,192	134,304	20,146
1988 :	12 months @ 12,312	147,744	22,162
1989 :	12 months @ 13,543	162,516	24,377
1990 :	12 months @ 14,897	178,764	26,815
1991 :	12 months @ 16,387	196,644	29,497
		FX$ 819,972	LS$ 122,997

Allowance

- Education	(5 years @ 20,000)	100,000
- COLA	(60 months @ 150)	9,000
- Misc.items	(5 years @ 1,000)	5,000
		$114,000

Travel and Transportation

- Internal travel and per diem		6,000
- Round trips @ $3,400 each 4 people x 4 trips x $3,400	54,000	6,000
- H.H. goods (2 times)	40,000	10,000
- Consumables, storage, unaccompanied baggage	60,000	10,000
	$154,000	LS$32,000
- Fee (10% of direct labor salary, differential, fringe, escalations	44,323	6,648
- Totals	FX$1,132,295	LS$161,645
- Use	FX$1,130,000	LS$160,000

8. Maintenance Engineer (Sept 86 - Apr 88) - 20 months
(family status, 2 children)

a)	Salary (uninflated)	$ 3,800 month
b)	Post differential (25%)	950 month
c)	Fringe (22%)	850 month
		$ 5,600 month
d)	Field overhead (85%)	4,760 month
		$10,360 month

Escalation of overhead and incremental salary increases (10% per annum)

		FX	LS$ (15%)
1985 :	0 months @ 10,360	-	-
1986 :	4 months @ 11,396	45,584	6,838
1987 :	12 months @ 12,536	150,438	22,565
1988 :	4 months @ 13,789	55,156	8,273
		$251,178	$37,676

Allowances

- Education	(2 years @ 20,000)	40,000	-
- COLA	(20 months @ 150)	3,000	-
- Misc. Items	(1.7 years @ 1,000)	1,700	-
		$ 44,700	-

Travel and Transportation

- Internal travel and per diem		6,000
- Round trips @ $3,400 each 4 people x 4 trips x $3,400	54,000	6,000
- H.H. goods (1 time)	20,000	5,000
- Consumables, storage, unaccompanied baggage	15,000	5,000
	$ 89,000	$22,000
- Fee (10% of direct labor salary, differential, fringe, escalations	13,577	2,037
- Totals	FX$398,455	LS$61,713
- Use	FX$400,000	LS$60,000

10. Short Term Technical Assistance - Design
(Design, Drainage and Soils Engineers - 40mm)

		FX in $	LS in $
a)	Salary 40mm @ $12,000 (Home office overhead and post differential)	480,000	72,000
b)	Allowances	16,000	20,000
c)	Travel: 8 round trips @ $3,400	27,200	3,200
d)	Fee @ 10% direct labor	21,300	4,800
	Total	FX$544,500	LS$100,000
	Use	FX$550,000	LS$100,000

11. Home Office Support

(Home Office managers with home office overhead)

a)	Salary 44 months @ $12,000	528,000	-
b)	Miscellaneous	12,000	-
c)	Fee @ 10% direct labor	23,500	-
	Total	FX$568,500	-
	Use	FX$570,000	-

12. Totals for Engineering Services

a)	Design services	550,000	100,000
b)	Construction & Maintenance Supervision & Training	8,970,000	1,310,000
c)	Kadugli-Dubiebat Road Rehabilitation	780,000	120,000
d)	Home Office Support	570,000	-
e)	Contingency(15% of items a,b,c)	1,630,000	230,000
	Total	FX$12,500,000	LS$1,760,000 (1)

(1) LS$1,760,000 = LS 3,696,000 @ 2.10 exchange rate

PART II
ECONOMIC ANALYSIS

H. Economic Analysis

1. Summary

This portion of the study covers the results of an economic feasibility analysis of constructing roads on the following alignments located in the South Kordofan area, south of Umm Ruwaba and El Obeid.

No.	Location
1A	Sherkeila - Balahat
1B	Barid - Sherkeila
1C	El Abbasiya - Barid
2C	Rashad - El Abbasiya
3A	Abu Gubeiha - Rashad
4A	Kologi - Abu Gubeiha
4B	Shagrabeth - Kologi
4C	Talodi - Shagrabeth
4D	Kadugli - Talodi

The study found that the overall alignment (Sherkeila to Kadugli) would be feasible. Discounted at 15 percent, the overall NPV would be LS24.7 million, while the IRR would be 29.8 percent. However, one segment (4A) was marginal, with an IRR of 17.3 percent, and another (4B) had an IRR of only 21 percent. The analysis is covered in detail in the remainder of this section. Attachment 3 is provided as a possible insert to a Project Paper. Attachment 4 contains the economic indicator calculations for all study roads.

2. The Area Transport System

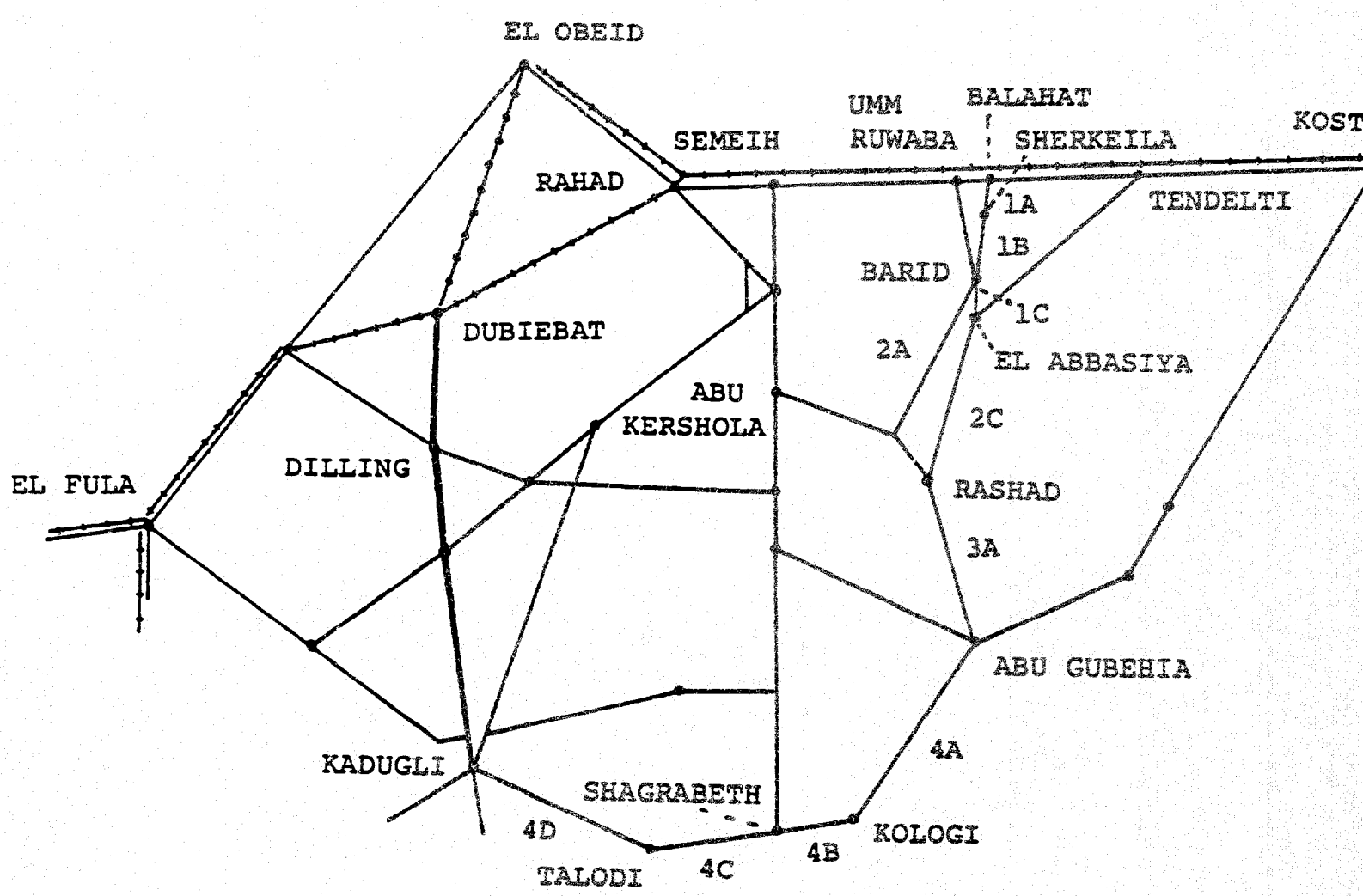
As shown by Figure H-1, the proposed road project would link Balahat on the Kosti-El Obeid road with Kadugli, the southern terminus of the El Obeid-Kadugli highway, serving El Abbasiya, Rashad, Abu Gubeiha, Kolodi and Talodi, enroute. With the paving of Kosti-El Obeid road scheduled for completion in 1990, the proposed project would improve access to the outside world for a sizeable segment of the Sudanese population, particularly during the rainy season. For example, the 1983 census indicated that the Rashad Area Council alone included some 328,000 people (1). Other than the El Obeid-Kadugli road to the west, which is gravel (El Obeid-Dubiebat) and asphalt (Dubiebat-Kadugli) the area is presently served only by numerous tracks, which can become completely impassable during the rainy season to all but tractors and similar vehicles.

The Nuba Mountain Corporation (NMC) a government entity, is presently involved in the maintenance of a number of these tracks. This organization supplies cotton seed to member farmers and plows their land for both cotton and dura cultivation, with the grain serving as a principal food crop. The NMC also purchases the cotton produced, gins it, and hauls it to the railhead at Semeih, for export. Tracks are maintained to the farms and to the buying stations which support the gins (six each for the gins at Talodi, Kolodi and Abu Gubeiha), plus two for the collection points at El Abbasiya. A track is also maintained from Shagrabeh, (a village between Talodi and Kologi) north to the Semeih railhead to support the movement of NMC cotton for export.

Other than the El Obeid-Kadugli highway, and numerous earthen tracks, the only other surface transport presently available in the vicinity of the study area is a line of the Sudan Railways, which parallels the planned Kosti-El Obeid highway. A branch of this line also runs to Dubiebat, where the NMC has a sizeable warehouse. The proposed connection of the Kologi-Talodi area with Kadugli could result in considerable diversion of cotton shipments from that area to the Dubiebat railhead, vs. the Semeih railhead.

The region served by the proposed roads is principally agricultural, producing livestock, oilseeds, dura and groundnuts, in addition to cotton. Since production of cotton (the primary crop) fluctuates with world prices, the tonnage exported annually from the area also varies. However, a recent agricultural development offers the possibility of a significant increase in area export tonnage. A new hybrid dura has been developed by representatives of the ICRISAT (the International Crop Research Institute for the Semi-Arid Tropics of Andura Pradesh, India), in cooperation with the Agricultural Research Corporation of Sudan. This new hybrid has produced 400 percent increases in test plot outputs.

(1) Third Population Census, Kordofan Region, Sudan, Nov 30, 1983.



SCHEMATIC-STUDY AREA TRANSPORT NET

RAILWAY
PAVED ROAD
GRAVEL ROAD
TRACK
1A STUDY ROAD

FIGURE E

The new grain is now being planted extensively for seed production, and the previous 4-fold increase in output has been maintained. Considering the present worldwide grain shortage, this new grain might provide the impetus for a switch from present area production of dura for consumption, to production for export. While part of the added production will doubtlessly be consumed by the farmers, there should be enough left to materially increase area exports. Although it is too early yet to predict the resulting impetus on highway traffic, the prospect appears promising.

3. Project Benefits

A conservative approach has been taken to specifying benefits for the proposed road project, with only vehicle operating costs (VOC) and passenger time considered. Full benefits were taken for normal and diverted traffic. However, only half of the benefits from generated traffic was considered. No credit was taken for the road's possible effect on area agricultural production. However, agricultural tonnage was included along with other factors in estimating the number of vehicles in the individual road segment AADT.

In assessing benefits, it was assumed that all segments of the proposed alignment would eventually be improved. Further, no allowances were made for the effect of possible future fuel shortages.

4. Traffic - General

In an environment such as the Southern Kordofan, traffic surveys may be more of an art than a science. For example, since fences are usually found only around built up areas, the vehicle driver roams freely over the landscape, limited only by the terrain and the capabilities of his vehicle. As a result, population centers are connected by multiple tracks, with traffic continually shifting from one to another as drivers search for optimum driving conditions. Under such circumstances, a traffic enumerator on one track could well miss vehicles on all the others. Partial traffic counts are, therefore, more likely to be the rule than the exception, with consequent possible understatement of normal traffic.

New traffic counts were not made for the current study, due to time restrictions. However, the cited limitations apply to the traffic data from previous studies which were used. The principal source of such data was a Norconsult study dated 1980 (2). This study covered the assigned alignment from Balahat (on the Kosti-Umm Ruwaba Road) south to Talodi. It did not include the remaining alignment between Talodi and Kadugli. This was covered by a Carl Bro Study, dated 1979 (3). Reliance was also placed upon a Louis Berger Study for recent vehicle operating costs (VOC) information (4).

(2) Norconsult, A.S., Sudan Feeder Roads Master Plan, Final Report, May 1980.

(3) Carl Bro, A.S., Economic & Technical Study of the Kadugli-Talodi Road, February 1979.

(4) Louis Berger, International, Inc., Economic Reappraisal of the Kosti-El Obeid Road, November 1983.

5. Normal Traffic

Study road segments upon which normal traffic was estimated are shown by Table H-1. The basic data upon which calculations were based for the various road alignments Balahat-Talodi are shown by Table H-2. Average annual daily traffic (AADT) was calculated from estimates of freight and passengers for the base year, which was Fiscal Year 1978-79. In order to reduce the volume of calculations, annual growth rates for different types of cargo were averaged, and applied to the base year totals. These rates are reasonable. All freight growth rates are under 5 percent, and passenger growth was 6 percent or less. The composition of traffic was also assumed to change over time, with a trend towards a lower proportion of medium trucks, with more large trucks, buses, light vehicles and passenger cars. This trend is in line with current experience.

In estimating the number of vehicles by type which would be required daily to handle the tonnage projected for a particular year, the following equation was used:

$$AADT = \frac{T.P}{L} \div 365$$

where AADT = Average annual daily traffic, for type vehicle

T = Total annual forecast tonnage.

P = Percent of total allocated to that type vehicle, that period

L = Average loading of type vehicle, that period, in tons

365 = Number of days per year.

A similar procedure was used in calculating the number of vehicles required to handle forecast passenger totals, with passengers substituted for tonnage.

Average passenger loads assigned to vehicles for calculating AADT were = medium truck - 20, bus - 30, light vehicle - 3 and passenger car - 7.

Where a vehicle was dual purpose, i.e. habitually carrying people and cargo at the same time (e.g. medium trucks and light vehicles), requirements were calculated separately and then netted, with only the higher figure then used. This procedure effectively eliminated possible double counting of freight and passenger requirements, for such vehicles.

For ease of reference, the road section numbers used in the Norconsult study were retained, with two exceptions. A different alignment was used for the Rashad-El Abbasiya Section (2A) which connected these two cities directly. The new alignment was similar to the Norconsult Section 2C, and this designation was used.

Table H-1

STUDY ROAD SEGMENTS

Segments Number	Location	Approximate Length Present Track (km)	Approximate Length New Alignment (km)
1A	Sherkeila - Balahat	13.0	12.0
1B	Barid - Sherkeila	50.0	50.0
1C	El Abbasiya - Barid	23.0	23.0
2C	Rashad - El Abbasiya	60.0	60.0
3A	Abu Gubeiha - Rashad	59.0	56.0
4A	Kologi - Abu Gubeiha	86.0	83.0
4B	Shagrabeth - Kologi	29.0	27.0
4C	Talodi - Shagrabeth	58.0	53.0
4D	Kadugli - Talodi	95.0	92.6
	Total	473.0	456.6

TABLE H-2

BASIC INPUT DATA ASSUMPTIONS

Section 1A = Sherkelia - Balahat

Vehicle Traffic Characteristics

Percent Freight Distribution		Med[1] Trk	Trk Tlr	Bus	Lt Veh	Car
* Yr	-1	97.5	1.5		0.5	
Yrs	0-3	97.5	1.5		0.5	
	4-9	92.5	7.0		0.5	
	10-20	79.5	20.0		0.5	6.0

Tons per Vehicle

Yr	-1	2.4	11.0		0.2	
Yrs	0-3	2.4	11.0		0.2	
	4-9	2.7	11.5		0.2	
	10-20	2.7	12.5		0.2	

Percent Passenger Distribution

* Yr	-1	96.5		3.0	0.5	
Yrs	0-3	96.5		3.0	0.5	
	4-9	82.0		14.0	4.0	
	10-20	65.0		25.0	4.0	6.0

Normal Traffic		Freight	Passengers
Volume	Yr-1	35,200 tons	208,000
Annual Growth Rate (%)			
Years	0-3	2.9	5.0
	4-9	3.5	5.2
	10-20	3.4	5.2

* Without road improvement, these assumptions apply for years -1 to 20.

(1) Med Trk = Medium truck; Trk Tlr = Truck/Trailer, a heavy truck; Lt Veh = Pickup or 4WD.

Section 1B: Barid - Skerkeila

Vehicle Traffic Characteristics

Percent Freight Distribution		Med Trk	Trk Tlr	Bus	Lt Veh	Car
*Yr	-1	98.0	2.0			
Yrs	0-3	98.0	2.0			
	4-9	90.0	10.0			
	10-20	70.0	30.0			

Tons per Vehicle

Yr	-1	2.3	11.0
Yrs	0-3	2.3	11.0
	4-9	2.3	11.5
	10-20	2.3	12.5

Percent Passenger Distribution

*Yr	-1	95.0		5.0		
Yrs	0-3	95.0		5.0		
	4-9	75.0		20.0	5.0	
	10-20	60.0		30.0	5.0	5.0

Normal Traffic		Freight	Passengers
Volume Yr -1		23,000	118,000
Annual Growth Rate (%)			
Years	0-3	3.6	6.0
	4-9	4.1	6.0
	10-20	3.8	6.0

* Without road improvement, these assumptions apply for years -1 to 20.

Section 1C = El Abbasiya-Barid

Vehicle Traffic Characteristics

Percent Freight Distribution		Med Trk	Trk Trlr	Bus	Lt Veh	Car
* Yr	-1	100.0				
Yrs	0-3	100.0				
	4-9	90.0	10.0			
	10-20	70.0	30.0			
Tons per Vehicle						
Yr	-1	2.3	11.0			
Yrs	0-3	2.3	11.0			
	4-9	2.3	11.5			
	10-20	2.3	12.5			
Percent Passenger Distribution						
* Yr	-1	86.5		12.5	1.0	
Yrs	0-3	86.5		12.5	1.0	
	4-9	70.0		25.0	5.0	
	10-20	50.0		40.0	5.0	5.0

Normal Traffic		Freight	Passengers
Volume Yr	-1	21,000 tons	109,000
Annual Growth Rate (%)			
Years	0-3	3.0	6.0
	4-9	3.4	6.0
	10-20	2.6	6.0

* Without road improvement, these assumptions apply for years -1 to 20.

Section 2C = Rashad - El Abbasiya

Vehicle Traffic Characteristics

Percent Freight Distribution		Med Trk	Trk Tlr	Bus	Lt Veh	Car
* Yr	-1	97.5	2.5			
Yrs	0-3	97.5	2.5			
	4-9	90.0	10.0			
	10-20	70.0	30.0			

Tons per Vehicle

Yr	-1	2.3	11.0
Yrs	0-3	2.3	11.0
	4-9	2.3	11.5
	10-20	2.3	12.5

Percent Passenger Distribution

* Yr	-1	93.0	6.0	1.0	
Yrs	0-3	93.0	6.0	1.0	
	4-9	75.0	20.0	5.0	
	10-20	60.0	30.0	5.0	5.0

Normal Traffic		Freight	Passengers
Volume Yr	-1	2,500 tons	16,000

Note: The above data were not used in calculating benefits for this section. Instead, normal traffic for the sections on either side (1C and 3A) were averaged and the average was used for Section 2C.

* Without road improvement, these assumptions apply for Years -1 to 20.

Section 3A: Abu Gubeiha - Rashad

Vehicle Traffic Characteristics

Percent Freight Distribution		Med Trk	Trk Tlr	Bus	Lt Veh	Car
* Yr	-1	97.0	3.0			
Yrs	0-3	97.0	3.0			
	4-9	90.0	10.0			
	10-20	70.0	30.0			

Tons per Vehicle

Yr	-1	2.3	11.0
Yrs	0-3	2.3	11.0
	4-9	2.3	11.5
	10-20	2.3	12.5

Percent Passenger Distribution

* Yr	-1	78.0		21.0	1.0	
Yrs	0-3	78.0		21.0	1.0	
	4-9	60.0		35.0	5.0	
	10-20	50.0		40.0	5.0	5.0

Normal Traffic		Freight	Passenger
Volume yr	-1	6,000 tons	82,000
Annual Growth Rate (%)			
Years	0-3	5.5	6.0
	4-9	5.5	6.0
	10-20	4.0	6.0

* Without road improvement, these assumptions apply for Years -1 to 20.

Section 4A: Kologi - Abu Gubeiha

Vehicle Traffic Characteristics

Percent Freight Distribution		Med Trk	Trk Tlr	Bus	Lt Veh	Car
* Yr	-1	96.0	4.0			
Yrs	0-3	96.0	4.0			
	4-9	90.0	10.0			
	10-20	70.0	30.0			

Tons per Vehicle

Yr	-1	2.3	11.0
Yrs	0-3	2.3	11.0
	4-9	2.3	11.5
	10-20	2.3	12.5

Percent Passenger Distribution

* Yr	-1	68.0	32.0		
Yrs	0-3	68.0	32.0		
	4-9	60.0	35.0	5.0	
	10-20	50.0	40.0	5.0	5.0

Normal Traffic		Freight	Passengers
Volume Yr -1		4,500 tons	53,000
Annual Growth Rate (%)			
Years	0-3	3.3	6.0
	4-9	3.3	6.0
	10-20	3.3	6.0

* Without road improvement, these assumptions apply for Years -1 to 20.

Section 4B: Shagrabeth - Kologi

Vehicle Traffic Characteristics

Percent Freight Distribution		Med Trk	Trk Tlr	Bus	Lt Veh	Car
* Yr	-1	94.0	6.0			
Yrs	0-3	94.0	6.0			
	4-9	90.0	10.0			
	10-20	70.0	30.0			

Tons per Vehicle

Yr	-1	2.3	11.0
Yrs	0-3	2.3	11.0
	4-9	2.3	11.5
	10-20	2.3	12.5

Percent Passenger Distribution

* Yr	-1	75.0		23.0	2.0	
Yrs	0-3	75.0		23.0	2.0	
	4-9	65.0		30.0	5.0	
	10-20	50.0		40.0	5.0	5.0

Normal Traffic		Freight	Passengers
Volume Year -1		11,400 tons	61,000
Annual Growth Rate (%)			
Years	0-3	3.3	6.0
	4-9	3.0	6.0
	10-20	3.0	6.0

* Without road improvement, these assumptions apply for Years -1 to 20.

Section 4C: Talodi - Shagrabeth

Vehicle Traffic Characteristics

Percent Freight Distribution	Med Trk	Trk Tlr	Bus	Lt Veh	Car
* Yr -1	95.0	5.0			
Yrs 0-3	95.0	5.0			
4-9	90.0	10.0			
10-20	70.0	30.0			

Tons per Vehicle

Yr -1	2.3	11.0
Yrs 0-3	2.3	11.0
4-9	2.3	11.5
10-20	2.3	12.5

Percent Passenger Distribution

* Yr -1	79.0	20.0	1.0	
Yrs 0-3	79.0	20.0	1.0	
4-9	65.0	30.0	5.0	
10-20	50.0	40.0	5.0	5.0

Normal Traffic	Freight	Passengers
Volume Yr -1	14,000 tons	73,000
Annual Growth Rate (%)		
Years 0-3	3.3	6.0
4-9	4.0	6.0
10-20	4.3	6.0

* Without road improvement, these assumptions apply for Years -1 to 20.

The new alignment had two advantages. First, it was shorter. Second, it allowed the El Abbasiya-Barid link to share in diverted traffic. Otherwise, El Abbasiya would be connected to Barid (to the north) by an extension of the Barid-Balahat road. The disadvantage of the new alignment was that it negotiates higher ground.

A different normal traffic was also used for Section 2C than for Section 2A. As shown by Figure H-1, Section 2A would have connected to a proposed Rashad-Abu Kershola alignment, northwest of Rashad. The proposed length was 92 kilometers as opposed to the 60 kilometer alignment selected for this study. This additional length could have led to considerable diversion to the more direct track, if the 2A alignment had been selected for construction. In any event, the Norconsult study assigned only 2500 tons of freight and 16,000 passengers of normal traffic to Section 2A for the base year, although diverted freight and passenger allocations were substantial. This assignment of normal traffic was not considered logical. Accordingly, normal passenger and vehicle traffic for the sections on either side of 2C (Sections 1C and 3A) were averaged, and the results used for initial traffic on Section 2C.

For ease of reference, the Kadugli-Talodi Section was also numbered as 4D. For the Kadugli-Talodi section, the normal traffic estimated by the Carl Bro study (AADT - 50 vehicles, 1977/89) was accepted, with the lesser of two proposed growth rates (3 percent per year vs 6 percent) proposed. The growth rates which were proposed by the Norconsult Study for the other roads were conservative and were adopted for the present analysis.

As indicated earlier, the Nuba Mountain Corporation maintains a track from the vicinity of Shagrabeth (north of Talodi) north to a railhead at Semeih. Cotton for export is hauled on this track, using principally tractor-trailers. However, this particular track was not considered in this study for a variety of reasons. First, it does not connect the area population centers, i.e. Kologi, Abu Gubeiha, Rashad and El Abbasiya. Second, a certain amount of traffic should be diverted from this track to the study roads when they are opened, using the railhead at Umm Ruwaba, via the one at Semeih. Third, with the opening of the route from Kologi west to Kadugli, there would also be a possibility of diverting part of the cotton traffic to the railhead at Dubiebat, via the one at Semeih.

6. Diverted Traffic

It was considered necessary to tie diverted traffic on the northern end of the project roads to traffic on the soon-to-be-paved Kosti-Umm Ruwaba road. A recent forecast of this traffic, which was available from the previously referenced Berger report, had already been accepted as reasonable and therefore represented a valid point of departure. The question then becomes, just how much of this traffic might be diverted to or from the study roads? In addition, there is a considerable (but unquantified) amount of traffic which now goes cross-country to and from Kosti from Abu

If the project roads were improved, much of this traffic would use them to reach the Kosti-El Obeid road. The eventual impact on traffic on the Kosti-El Obeid road would be a net of these two diversion effects.

The amount of traffic on a particular road which is diverted to and from the Kosti-El Obeid road should vary inversely with distance from the latter road. Section 1A, which connects directly to the Kosti-Umm Ruwaba road should, therefore, have a higher level of diverted traffic than Section 4B (Shagrabeth-Kologi) which is far to the south. Accordingly, it was assumed that the net diversion to/from effect described earlier could result in the addition of the equivalent of 4 percent of the Kosti-Umm Ruwaba AADT during the critical years, to road sections connecting Balahat, Barid, El Abbasiya, Rashad and Abu Gubeiha. This comprises Sections 1A, 1B, 1C, 2C and 3A. For Section 4A (Kologi-Abu Gubeiha) the rate was reduced to 3 percent, and for Section 4B (Shagrabeth-Kologi), 2 percent was used.

These diversion estimates are considered very conservative. For example, during the opening year for Section 1A (1990-91) the diverted AADT would only be 11 - medium trucks and buses, 2 - truck/trailers and 4 light vehicles or cars. In the final year of the analysis period for this section (2909-10), comparable diverted AADT figures would be 21, 8 and 13. A review of normal traffic estimates will indicate that the development of this traffic as forecast is a prerequisite to the economic viability of the proposed road segments. This is a principal reason for ensuring that a conservative estimate was used.

From Shagrabeth west, diversion traffic was assumed to be oriented towards the Kadugli-El Obeid road, rather than the Kosti-Umm Ruwaba highway. The Carl Bro study proposed a beginning AADT for diverted traffic of 20 vehicles. This was considered as unsubstantiated, and a starting AADT for diverted traffic of 5 vehicles (10 percent of normal traffic) was estimated, with a 3 percent annual growth rate. At the final year (2008-09), these data would result in a diversion of 13 vehicles per day. Diverted traffic for Section 4C (Talodi-Shagrabeth) was estimated at 5 percent of normal traffic, due to its nearness to the primary Kadugli-El Obeid road.

For consistency, it was necessary to establish a connection between the number of vehicles diverted and the number of passengers for whom benefits were calculated. This was accomplished by loading the diverted vehicles at the prescribed rates.

7. Generated Traffic

The new road should result in generation of an undetermined amount of passenger and freight traffic. The Norconsult Study cites evidence of an immediate increase of passenger traffic of 20 percent, incident to a road opening. This was considered too high, and a figure of 10 percent of normal traffic was assumed, for combined passenger and freight generation. This should ensure that the results are sufficiently conservative.

8. Traffic Projections and Vehicle Mixes

For consistency of results, the vehicle mixes used in AADT calculations for Sections 1A through 4C were as outlined in Table H-2 from the Norconsult Study. Likewise, the mixes used with Section 4D (Kadugli-Talodi) are based upon criteria from the Carl Bro study. Likewise, the traffic diverted to/from the Kosti-El Obeid road was taken in the vehicle proportions specified by the Berger Study on that road. The results are shown by Table H-3 for opening and final years for each road segment by type vehicle and traffic. In this Table, year -1 is the base year, 1978/79. Normal traffic growth was based on data for this year. Diverted and generated traffic and changes in vehicle mix were assumed to start only when a road opened. Table H-4 shows the AADT forecast, by vehicle type, for each road segment for each of the analysis years. In developing these estimates. traffic was forecast for each of the critical years (those at which vehicle mixes changed) with intervening year traffic then interpolated. This procedure resulted in some underestimation of requirements in the earlier years, but it avoided the abrupt changes in year-to-year AADT which would have otherwise resulted, principally in medium trucks/buses. This resulted in a more real-life progression of traffic and enhanced the conservative nature of the result.

Table H-4 shows AADT for consolidated vehicle types by VOC level, i.e., medium trucks and buses and combined, as are light vehicles and cars.

9. Vehicle Operating Cost Savings

Vehicle operating cost (VOC) benefits are realized on normal, diverted and generated vehicle traffic. The differences in VOC on the existing road versus that on the improved road is the basis for these benefits, which are calculated on an annual basis. As indicated earlier, basic VOC for the present study were taken from the referenced Berger Study. The basic data from the Berger Study are reproduced here on Table H-5. These data are for a 6-ton truck, a Bedford or Austin. The values shown compare favorably with previous Norconsult study results, when properly inflated.

Based upon the information shown in Table H-5, Berger derived a table reflecting VOC relationships between vehicle types and road surfaces. This table is reproduced here as Table H-6. It will be noted that this table shows three levels of VOC, depending upon the severity of the surface conditions. In order to ensure a conservative result, the lowest cost section (El Obeid-Umm Ruwaba) was selected as the basis for conversion to clay surface costs. The conversion was necessary because 60-70 percent of the soils through which the study road alignments pass are either clay or clay mixtures. The results are shown in Table H-7, which also includes escalation (at 37.5 percent) to account for inflation between mid 1983 and January 1985.

Table H-3

TRAFFIC PROJECTIONS BY TYPE VEHICLE AND TRAFFIC

No.	Section	Med/Trk-Bus	Trk/Tlr	Lt Veh/Car	Total
1A	Sherkelia-Balahat				
	Open Years (1990-91)				
	Normal	59	1	4	64
	Diverted	11	2	4	17
	Generated	6			6
	Total	76	3	8	87
	Final Years (2009-10)				
	Normal	120	4	61	185
	Diverted	21	8	13	42
	Generated	12		5	17
	Total	153	12	79	244
1B	Barid-Balahat				
	Open Years (1990-91)				
	Normal	43	2	-	45
	Diverted	11	2	4	17
	Generated	4	-	-	4
	Total	58	4	4	66
	Final Years (2009-10)				
	Normal	74	4	17	95
	Diverted	21	8	13	42
	Generated	7		2	9
	Total	102	12	32	146
1C	El Abbasiya-Barid				
	Open Years (1990-91)				
	Normal	39	-	2	41
	Diverted	11	2	4	17
	Generated	4	-	-	4
	Total	54	2	6	62
	Final Years (2009-10)				
	Normal	69	4	44	117
	Diverted	21	8	13	42
	Generated	7	-	5	12
	Total	97	12	62	171

No.	Section	Med/Trk-Bus	Trk/Tlr	Lt Veh/Car	Total
2C	Rashad-Al Abbasiya				
	Open Years (1990-91)				
	Normal	32	-	2	34
	Diverted	11	2	4	17
	Generated	3	-	-	3
	Total	46	2	6	54
	Final Years (2009-10)				
	Normal	67	3	41	111
	Diverted	21	8	13	42
	Generated	7	-	5	12
	Total	95	11	59	165
3A	Abu Gubeiha-Rashad				
	Open Years (1992-93)				
	Normal	24	-	2	26
	Diverted	11	3	5	19
	Generated	2	-	-	2
	Total	37	3	7	47
	Final Years (2011-12)				
	Normal	58	1	37	96
	Diverted	23	9	14	46
	Generated	6	1	4	11
	Total	87	11	55	153
4A	Kalogi-Abu Gubeha				
	Open Years (1996-97)				
	Normal	15	-	-	15
	Diverted	9	2	3	14
	Generated	1	-	-	1
	Total	25	2	3	30
	Final Years (2011-12)				
	Normal	39	1	24	64
	Diverted	16	6	9	31
	Generated	4	1	3	8
	Total	59	8	36	103

No.	Section	Med/Trk-Bus	Trk/Tlr	Lt Veh/Car	Total
4B	Shagrabeih-Kalogi				
	Open Years (1991-92)				
	Normal	21	-	2	23
	Diverted	6	1	2	9
	Generated	2	-	-	2
	Total	29	1	4	34
	Final Years (2010-11)				
	Normal	39	3	27	69
	Diverted	11	4	7	22
	Generated	5	-	3	8
	Total	55	7	37	99
4C	Talodi-Shagrabeih				
	Open Years				
	Normal	27	1	1	29
	Diverted	1	-	-	1
	Generated	1	-	-	1
	Total	29	1	1	31
	Final Years				
	Normal	55	3	32	90
	Diverted	3	-	2	5
	Generated	3	-	1	4
	Total	61	3	35	99
4D	Kadugli-Talodi				
	Open Years (1989-90)				
	Normal	64	3	4	71
	Diverted	5	1	1	7
	Generated	5	1	1	7
	Total	74	5	6	85
	Final Years (2008-09)				
	Normal	113	6	16	128
	Diverted	10	1	2	13
	Generated	10	1	1	12
	Total	133	8	19	150

Table H-4

FORECAST AADT - BY ROAD, YEAR AND TYPE VEHICLE

1A - Sherkelia-Balahat

Year	M-Trk/ Bus	Trk/ Tlr	Lt Veh/ Car	TOTAL
1990-91	76	3	8	87
92	77	3	11	91
93	79	4	14	97
94	80	4	18	102
95	82	4	24	110
96	84	4	27	115
97	86	5	30	121
98	88	6	34	128
99	90	6	39	135
00	92	7	44	143
01	94	8	49	151
02	99	8	52	159
03	105	9	54	168
04	111	9	57	177
05	117	10	61	188
06	123	10	64	197
07	139	10	67	207
08	137	11	71	219
09	145	11	71	231
10	153	12	79	244

1B - Barid-Sherkelia

M-Trk/ Bus	Trk/ Tlr	Lt Veh/ Car	TOTAL
58	4	4	66
60	4	4	68
62	4	5	71
65	5	5	75
67	5	6	78
68	5	7	80
68	6	9	83
69	6	10	85
70	7	12	89
70	7	15	92
71	8	18	97
74	8	19	101
77	9	20	106
80	9	22	111
83	10	23	116
87	10	24	121
90	10	26	126
94	11	27	132
98	11	27	138
102	12	31	146

1C - El Abbasiya-Barid

Year	M-Trk/ Bus	Trk Tlr	Lt Veh/ Car	TOTAL
1990-91	54	2	6	62
92	55	2	9	66
93	56	3	14	73
94	58	3	22	83
95	59	4	34	97
96	61	4	34	99
97	63	5	34	102
98	65	6	34	105
99	67	6	35	108
00	69	7	35	111
01	71	8	35	114
02	74	8	37	119
03	76	9	40	125
04	79	9	42	130
05	82	10	45	137
06	84	10	48	142
07	87	10	51	148
08	91	11	55	157
09	94	11	58	163
10	97	12	62	171

2C - Rashad-El Abbasiya

M-Trk Bus	Trk Tlr	Lt Veh/ Car	TOTAL
46	2	6	54
47	2	8	57
48	3	11	62
50	3	15	68
51	4	20	75
53	4	22	73
55	5	24	84
57	5	26	88
59	6	28	93
61	6	31	98
68	7	34	104
66	7	37	110
69	8	40	117
72	8	43	123
76	9	47	132
79	9	50	138
83	9	54	145
87	10	59	156
91	10	64	165
95	11	59	165

Table H-4 (con't.)

FORECAST AADT - BY ROAD, YEAR AND TYPE VEHICLE

3A - Abu Gubeiha-Rashad

Year	M-Trk/ Bus	Trk/ Trl	Lt Veh/ Car	TOTAL
1992-93	37	3	7	47
94	38	3	9	50
95	39	4	11	54
96	41	4	14	59
97	42	5	18	65
98	44	5	20	69
99	45	6	22	73
00	47	6	24	77
01	49	7	26	82
02	51	7	29	87
03	53	8	32	93
04	56	8	34	98
05	59	9	36	104
06	63	9	38	110
97	66	9	41	116
08	70	10	43	123
09	74	10	46	130
10	78	10	49	137
11	82	11	52	145
12	87	11	55	153

4A - Kalogi-Abu Gebeha

M-Trk/ Bus	Trk/ Trl	Lt Veh/ Car	TOTAL
25	2	3	30
26	2	4	32
26	2	6	34
27	2	8	37
28	2	12	42
29	2	13	44
30	3	13	46
32	3	14	49
33	4	15	52
35	4	16	55
37	5	17	59
38	5	18	61
40	5	19	68
43	6	20	69
45	6	21	72
48	6	22	76
51	6	24	81
54	6	25	85
57	7	26	90
60	7	36	103

4B - Shagrabeth-Kalogi

Year	M-Trk/ Bus	Trk/ Trl	Lt Veh/ Car	TOTAL
1991-92	29	1	4	34
93	31	1	5	37
94	33	1	7	41
95	36	2	9	47
96	38	2	12	52
97	38	2	13	53
98	38	3	15	56
99	38	3	16	57
00	39	4	18	61
01	39	4	20	63
02	39	5	22	66
03	41	5	23	69
04	43	5	25	73
05	44	6	26	76
06	45	6	28	79
07	47	6	29	82
08	49	6	31	86
09	51	6	31	90
10	53	7	35	95
11	55	7	37	99

4C - Talodi-Shagrabeth

M-Trk/ Bus	Trk/ Trl	Lt Veh/ Car	TOTAL
29	1	1	31
31	1	1	34
32	1	3	36
34	1	5	40
36	1	9	46
37	1	10	48
38	1	12	51
39	1	14	54
40	2	16	58
41	2	18	61
42	2	21	65
44	2	22	68
46	2	24	72
48	2	25	75
50	2	26	78
52	3	28	83
54	3	30	87
56	3	31	90
59	3	33	95
61	3	35	99

Table H-4 (con't.)

FORECAST AADT - BY ROAD, YEAR AND TYPE VEHICLE

4D - Kadugli-Talodi

Year	M-Trk/ Bus	Trk/ Trl	Lt. Veh/ Car	TOTAL
1989-90	74	5	6	85
91	76	5	6	87
92	78	5	6	89
93	81	5	6	92
94	83	5	7	95
95	86	6	7	99
96	88	6	7	111
97	91	6	7	104
98	94	6	7	107
99	96	6	7	109
00	99	6	7	112
01	102	6	7	115
02	105	7	8	120
03	108	7	8	123
04	112	7	8	127
05	115	7	8	130
06	118	7	8	133
07	122	7	8	137
08	125	8	9	142
09	133	8	9	150

Table H-5

ECONOMIC TRUCK OPERATING COSTS ON SAND IN KORDOFAN

(Mid 1983)

	Pounds Sudanese
Vehicle: Bedford or Austin - 6 ton (1)	
Cab and frame	38,000
Body and reinforcement	6,500
- tires (included below)	- 2,200
Initial Value	42,300
Residual Value (50% after 6 years)	21,150
Present value of residual vehicle at 12%	- 10,700
Amount to be depreciated	31,600
Yearly Costs	
Depreciation (at 12% over 6 years)	7,700
Insurance	100
Maintenance	3,300
Driver (plus 2 assistants)	4,000
Fuel	13,600
Oil and lubricants	1,400
Tires	3,800
Overhead	4,100
TOTAL	38,000

Yearly use	30,000 km
VOC per km	1.27Ls.

(1) Louis Berger International, Economic Reappraisal of the Kosti - El Obeid Road, November, 1983, Table 4.1

Table H-6

ECONOMIC VEHICLE OPERATING COSTS PER KM (KORDOFAN)

(MID 1983)

Road Location/Type (1)	Passenger Cars/Pickups	Medium Trucks/Buses	Heavy Trucks
El Obeid - Umm Ruwaba			
Sand	0.57	1.24	2.13
Paved	0.23	0.47	0.47
Saving	0.34	0.77	1.39
Umm Ruwaba - Tendelti			
Sand	0.85	1.27	2.17
Paved	0.23	0.47	0.74
Saving	0.42	0.80	1.43
Tendelti - Kosti			
Sand	0.74	1.30	2.21
Paved	0.23	0.47	0.74
Saving	0.51	0.83	1.47

(1) Louis Berger International, Economic Reappraisal of the Kosti-El Obeid Road, November 1983, Table 4.2

Table H-7

VOC DERIVATION

Item	Medium Truck	Truck Trailer	Bus	Light Veh.	Car
1. VOC for sand surface, mid 1983(1)	1.24	2.13	1.24	0.57	0.57
2. Inflation to Jan 1985 (x 1.375)(2)	1.71	2.93	1.71	0.78	0.78
3. Convert to clay surface (x 1.03)(3)	1.76	3.01	1.76	0.81	0.81
4. VOC for paved surface(1)	0.47	0.74	0.47	0.23	0.23
5. Inflation to Jan 1985 (x 1.375)(2)	0.64	1.02	0.64	0.32	0.32
6. Convert to gravel VOC (LS x 1.16)(4)	0.74	1.18	0.74	0.37	0.37
7. VOC saving, gravel road vs clay track (L3-L6)	1.02	1.83	1.02	0.44	0.44

(1) From Louis Berger International, Economic Reappraisal of the Kosti-El Obeid Road, November 1983, Table 4.2

(2) Raised from mid-1983 VOC to January 1985 level.

(3) Increases sand surface VOC to clay surface VOC, with surface wet 5 months and dry 7 months. Based on relationships determined in Norconsult, A.S., Sudan Feeder Roads Master Plan, Final Report, Part B, May 1980, p.2-51 which indicates that VOC for a medium truck (Feb-Mar 1979) for operation on loose sand were 2.12 milliemes per km via a similar cost of 2.19 milliemes for operation on the cited clay surface. The clay surface VOC was 3 percent higher.

(4) Ibid. VOC for bituminous surface @ 82 milliemes per km, compared to 95 milliemes per km for good gravel (95 ÷ 82 = 1.16).

10. VOC Benefits

In calculating VOC benefits, the consumers' surplus approach was used. This technique involves the following equation and was computed separately for each vehicle type:

$$CB = \frac{1}{2} (V_1 + V_2) \quad (P_1 - P_2) \; (K) \quad (Y)$$

Where CB = Consumers' surplus

V_1 = Average annual daily traffic, existing road

V_2 = Average annual daily traffic, improved road

P_1 = VOC per km, existing road

P_2 = VOC per km, improved road

K = Road length, in km

Y = Year (365 days)

11. Time Savings

In determining a reasonable cost for passengers' time, interviews were conducted in the area of influence of the study road. Based on the results, unskilled labor was priced at LS 3.50 per day or LS 0.50 per hour for a 7 hour day. Skilled labor was likewise priced at LS 8.00 per day or LS 1.14 per hour, and administrative/other labor at LS 16.00 per day or LS 2.29 per hour.

In calculating passenger time benefits, the number of passengers in normal traffic was calculated, using the growth rates outlined in Table H-2. The number of passengers on diverted vehicles was then estimated, using the loading rates which were noted previously. Finally, the number of passengers in generated traffic was calculated, at 10 percent of normal passenger traffic. The total was then disaggregated to unskilled, skilled and administrative/other categories, using respective multiplier of 75, 15 and 10 percent. The multipliers were used in the Norconsult study and are still applicable. Each category was then multiplied by the appropriate wage rate and the hours of travel or fractions thereof, in tenths, which was saved by one travelling the improved vs the existing road. In estimating time saved by using the improved road instead of a track, average running speeds from the Norconsult Study (5) were compared, for a gravel road and a track. Comparative speeds of 52 kph for a gravel road and 30 kph for a track, were derived. Only half of the benefits from generated traffic was taken.

12. Economic Indicators

Tables H-8 and H-9 shows cost and benefits for each of the nine road segments. In each case, the first two entries under cost are construction costs, with the remaining entries attributed to periodic and routine maintenance. The last figure in the benefit column is the salvage value of the road and structures. Table H-10 breaks out benefits.

Table H-11 shows NPV and IRR for each of the road segments. In calculating the NPV, a 15 percent discount factor was used, and cost/benefits data were discounted back to the same base year for all roads, 1986/87. Table H-11 is based upon tables in Attachment 4, which show NPV and IRR circulations for each road segment.

(5) Norconsult, A.S., Sudan Feeder Roads, Master Plan, Final Report, Part B, Methods, Parameters and Results, May 1980, p2.62

Table H-8

ANNUAL ROAD SEGMENT COSTS

Year	ROAD SEGMENT 1A(1)	1B	1C	2C	3A	4A	4B	4C	4D	TOTAL
	(LS 000)									
1986/87										
88									3573	3573
89	529(2)	2268	1114	2369					2382	8662
90	353	1572	743	1579			1069	2047	75	7488
91	10(3)	41	19	49	2011	3518	713	1398	75	7834
92	10	41	19	49	1341	2345	22	43	75	3945
93	10	41	19	49	46	68	22	43	462	760
94	61(4)	252	116	303	46	68	22	43	75	986
95	10	41	19	49	46	68	136	267	75	711
96	10	41	19	49	283	419	22	43	75	961
97	10	41	19	49	46	68	22	43	75	373
98	10	41	19	49	46	68	22	43	462	751
99	61	252	116	303	46	68	22	43	75	986
2000	10	41	19	49	46	68	136	267	75	711
01	10	41	19	49	283	419	22	43	75	961
02	10	41	19	49	46	68	22	43	75	373
03	10	41	19	49	46	68	22	43	462	760
04	61	252	116	303	46	68	22	43	75	986
05	10	41	19	49	46	68	136	267	75	711
06	10	41	19	49	283	419	22	43	75	961
07	10	41	19	49	46	68	22	43	75	373
08	10	41	19	49	46	68	22	43	462	760
09	61	252	116	303	46	68	22	43	75	986
2010	10	41	19	49	46	68	136	267		636
11					283	419	22	43		767
12					46	68				114

(1) Segment designations:
- 1A = Sherkeila-Balahat
- 1B = Barid-Sherkeila
- 1C = El Abbasiya-Barid
- 2C = Rashad-El Abbasiya
- 3A = Abu Gubeiha-Rashad
- 4A = Kologi-Abu Gubeiha
- 4B = Shagrabeh-Kologi
- 4C = Tolodi-Shagrabeh
- 4D = Kadugli-Talodi

(2) First two years are construction costs. (3) Routine Maintenance. (4) Periodic Maintenance

Table II-9

ANNUAL ROAD SEGMENT BENEFITS

Year	ROAD SEGMENTS 1A(1)	1B	1C	2C	3A	4A	4B	4C	4D	TOTAL
	(LS 000)									
1986/87										
88										
89										
90									2854	2854
91	407(2)	1233	549	1037					2947	6173
92	424	1305	570	1097			335	778	3043	7552
93	442	1382	592	1161	936	905	369	828	3142	9757
94	461	1462	615	1228	998	960	406	880	3244	10254
95	481	1548	639	1299	1065	1018	448	936	3350	10784
96	503	1576	656	1358	1136	1079	493	996	3559	11356
97	526	1604	674	1421	1211	1145	508	1045	3572	11706
98	550	1633	692	1486	1278	1220	524	1096	3688	12167
99	575	1662	710	1554	1348	1301	540	1150	3809	12649
2000	602	1692	729	1625	1423	1387	556	1207	3933	13154
01	629	1722	749	1699	1502	1478	573	1265	4061	13678
02	662	1795	794	1790	1584	1575	591	1328	4193	14312
03	696	1871	842	1886	1672	1679	616	1392	4330	14984
04	732	1951	892	1987	1763	1769	642	1459	4471	15666
05	771	2033	946	2094	1860	1863	669	1530	4616	16382
06	811	2119	1003	2206	1962	1962	697	1603	4767	17130
07	853	2209	1063	2324	2069	2067	727	1681	4922	17915
08	897	2303	1127	2448	2181	2177	757	1768	5082	18735
09	944	2401	1194	2579	2301	2293	789	1847	5241	19589
2010	993(2)	2501	1266	2718	2427	2416	822	1936	4412	19491
11	687	2820	1335	2802	2559	2544	857	2029		15633
12					2700	2680	1284	3810		10474
13					2469	4357				6823

(1) Segment designations:
- 1A = Sherkeila-Balahat
- 1B = Barid-Sherkeila
- 1C = El Abbasiya-Barid
- 2C = Rashad-El Abbasiya
- 3A = Abu Gubeiha-Rashad
- 4A = Kologi-Abu Gubeiha
- 4B = Shagrabeh-Kologi
- 4C = Talodi-Shagrabeh
- 4D = Kadugli-Talodi

(2) First figure is opening year benefit. Next to last figure is final year benefit.

Table H-10

STUDY ROAD BENEFITS - VOC VS PASSENGER

ROADS/BENEFITS

Year Benefit	1A	1B	1C	2C (LS000)	3A	4A
1990-91						
VOC	337.0	1038.2	460.6	939.0		
Pass.	70.3	194.7	88.2	98.1		
Total	407.3	1232.9	548.8	1037.1		
1994-95						
VOC	396.0	1311.9	532.0	1231.8		
Pass.	84.8	236.1	107.0	95.8		
Total	480.8	1548.1	639.0	1298.5		
2000-01						
VOC	516.8	1409.9	650.1	1569.0		
Pass.	112.0	312.5	144.1	130.1		
Total	622.8	1722.4	794.2	1699.1		
2009-10						
VOC	824.1	1993.5	1017.8	2560.1		
Pass.	168.9	507.3	248.2	157.9		
Total	993.0	2500.8	1266.0	2718.0		
1992-93						
VOC					748.1	710.5
Pass.					187.7	194.3
Total					935.8	904.8
1996-97						
VOC					985.0	918.2
Pass.					226.1	227.1
Total					1211.1	1145.3
2002-03						
VOC					1361.5	1372.2
Pass.					310.0	306.4
Total					1671.5	
2011-12						
VOC					2190.7	2194.4
Pass.					509.0	485.9
Total					2699.7	2680.3

Table H-10

STUDY ROAD BENEFITS - VOC VS PASSENGER

ROADS/BENEFITS

Year/ Benefit	4B	4C	4D
1991-92			
VOC	278.1	636.9	
Pass.	57.3	141.0	
Total	335.4	777.9	
1995-96			
VOC	424.2	827.8	
Pass.	68.5	168.6	
Total	492.7	996.4	
2001-02			
VOC	498.2	1088.8	
Pass.	92.9	239.3	
Total	591.1	1328.1	
2010-11			
VOC	702.4	1626.4	
Pass.	154.8	402.7	
Total	857.2	2029.1	
1989-90			
VOC			2097.0
Pass.			146.0
Total			2243.0
2008.09			
VOC			3674.0
Pass.			468.8
Total			4142.8

Table H-11

SUMMARY - ROAD SEGMENT ECONOMIC INDICATORS

NO.	SEGMENT	NPV[1] (LS000)	IRR (Percent)
1A	Sherkeila-Balahat	1,493	40.1
1B	Barid-Sherkeila	3,447	30.1
1C	El Abbasiya-Barid	1,417	27.6
2C	Rashad-El Abbasiya	2,697	26.0
3A	Abu Gubeiha-Rashad	2,143	28.0
4A	Kologi-Abu Gubeiha	595	17.3
4B	Shagrabeh-Kologi	541	21.0
4C	Talodi-Shagrabeh	1,508	23.1
4D	Kadugli-Talodi	10,841	40.2

(1) Using a 15 percent discount rate

13. Sensitivity Tests

Sensitivity tests applied in the study road analysis included:

Case	Test
A	Discount rate @ 10 percent per year.
B	Discount rate @ 18 percent per year.
C	Construction costs @ + 20 percent, discount rate @ 15 percent per year.
D	Benefits @ - 15 percent, discount rate @ 15 percent per year.

Case A. As shown by Table H-12, when the discount rate was reduced to 10 percent per year, NPV's increased significantly, with results ranging from LS1.608 million for Road 4B (Shagrabeth-Kologi) to LS19.355 million for Road 4D (kadugli-Talodi). The IRR's would not change from those calculated earlier for the 15 percent discount rate, because the basic input data would not change.

Case B. The raising of the discount rate to 18 percent per year resulted in drastic reductions in some of the NPV's. For example, the NPV for Road 4A (Kologi-Abu Gabehia) dropped to a -LS139,000. Similarly, the NPV for Road 4B (Shagrabeih-Kologi) was reduced to LS208,000. Other roads continued to show profitability.

Case C. When construction costs were increased by 20 percent (with a 15 percent discount rate), the NPV for Road 4A fell to a -LS41,000, and the IRR dropped to 14.9 percent. Likewise, the NPV for Road 4B decreased (to LS318,000), and the IRR fell to 12 percent. Again, the other roads did comparatively well.

Case D. When benefits were decreased by 15 percent (again with a 15 percent discount rate), the NPV for Road 4A fell to a -LS30,000, with an IRR of 14.9 percent. The NPV for Road 4B fell to 271,000, with an IRR of 18.1 percent. Other roads remained in comparatively better shape.

14. Recapitulation

As the South Kordofan region continues to grow, traffic on the key arterial roads planned for the area (Kosti-El Obeid and El Obeid-Kadugli) can be expected to keep pace. Routings which collect and channel traffic (which is now using tracks) to these key roads can also expect significant gains. As the distance from these roads grow, the volume of this channeled traffic should decrease, as the perception of a reduced trip length cross-country begins to outweight the attractions of a more comfortable, lower VOC (but longer) route. This tendency is reflected by the various feasibility tests which have been applied to the study roads, with alignments 4A (Kologi-Abu Gubeiha)

Table H-12

SENSTIVITY TEST RESULTS

NO.	SEGMENT	CASE A NPV @ Disc 10%	CASE B Rates of 18%	CASE C Const Costs @+20% NPV(1)	CASE C IRR	CASE D Benefits @-15% NPV(1)	CASE D IRR
		(----------LS10⁶	----------)		(%)	(LS10⁶)	(%)
1A	Sherkeila-Balahat	2.829	1.032	1.366	34.9	1.162	35.2
1B	Barid-Sherkeila	7.111	2.194	2.898	26.0	2.471	26.2
1C	Abbasiya-Barid	3.086	0.855	1.151	23.9	0.983	24.1
2C	Rashad-El Abbasiya	6.139	1.549	2.131	22.6	1.811	22.7
3A	Abu Gubeiha-Rashad	5.116	1.231	1.779	24.4	1.509	24.5
4A	Kologi-Abu Gubahia	3.230	-0.139	-0.041	14.9	-0.030	14.9
4B	Shagrabeth-Kologi	1.608	0.208	0.318	18.0	0.271	18.1
4C	Talodi-Shagrabeth	4.013	0.728	1.073	20.0	0.912	20.1
4D	Kadugli-Talodi	19.355	7.761	9.859	34.8	8.379	35.2

(1) As discount rate of 15 percent per year.

and 4B (Shagrabeth-Kologi) consistently doing worse than the other roads. As indicated by the schematic (Figure H-1) these roads are at a maximum distance from the principal roads, and should therefore tend to share least in benefits of diversion. The tests consistently show Road 4A (Kologi-Abu Gebeiha) as marginal, and Road 4B (Shagrabeth-Kologi) is not a great deal better. The remainder of the road segments appear to offer excellent chances for proving out as feasible. Overall, granting the assumptions which have been made, the net present value of the entire alignment is LS24.7 million (at a 15 percent per year discount rate) and the IRR is 29.8 percent). An inordinate share of this performance (e.g., an NPV of LS10.8 million), is attributable to Road 4D (Kadugli-Talodi), a relatively long segment which connects to the principal El Obeid -Kadugli highway. However, in the case of this road, as with the others, an attempt has been made to ensure that traffic estimates (and resulting benefits) were kept at conservative levels. Accordingly, the chances of realizing these estimates would appear to be fairly good.

PART III
ATTACHMENTS

ATTACHMENT 1

COMPARATIVE COST OF TYPICAL SECTIONS

For a comparison between the cost per kilometer of 4, 5.5 and 6 meter alternative roadway widths, it was assumed that the following was the same for each alternative:

1. Borrow haul distance of 10km.
2. Volume and cost of side ditch excavation.
3. Formation height of 0.50 meters.
4. Clearance width of 30 meters.
5. Gravel haul distance of 15km.

1. Typical Section 4 Meters Wide

a) Earthworks

Formation volume	= 0.5m [2(4.6m) + 4(0.50m)] (1000m)½	= 2,800m^3/km
Formation cost	= 2,800m^3/km x LS 3.00/m^3	= LS8400/km
Ditch cost	= 1,440m^3/km x LS 2.50/m^3	= LS3600/km
Haulage	= 2,800m^3/km x 10km x LS 0.50/m^{3}km	= LS14000/km
Clearing	= 30m x 1000m x LS 0.18/m^2	= LS5400/km
	TOTAL EARTHWORK COST	LS31400

b) Gravel Surfacing 150 mm Thick

Volume	= 0.15m[2(4m) + 4(0.15m)] (1000m)½	= 645m^3/km
Gravel cost	= 645m^3/km x LS 8.00/m^3	= LS 5160
Haulage	= 645m^3/km x (15-1)km x LS 0.50/m^{3}km	= LS 4515
	TOTAL GRAVEL SURFACING COSTS	LS 9675
	USE	LS 9700

c) Total Cost Earthworks and Gravel Surfacing LS41100

2. Typical Section 5.5 Meters Wide

a) Earthworks

Formation volume	= 0.50m [2(6.1m) + 4(0.50m)] (1000m)½	= 3,550m^3/km
Formation Cost	= 3,550m^3/km x LS 3.00/m^3	= LS10,650/km
Side Ditches	=	= LS 3,600/km
Haulage	= 3,550m^3/km x 10km x LS 0.50/m^{3}km	= LS17,750/km
Clearing		= LS 5,400/km
	TOTAL EARTHWORK COST	LS37,400/km

b) Gravel Surfacing 150mm Thick

Volume	= 0.15m[2(5.5m) + 4(0.15m)] (1000m)½	= 870m^3/km
Gravel Cost	= 870m^3/km x LS 8.00/m^3	= LS 6,960/km
Haulage	= 870m^3/km x (15.1)km x LS 0.50/m^{3}km	= LS 6,090/km
	TOTAL GRAVEL COST	LS13,050/km
	USE	LS13,000/km

c) Total Cost Earthworks and Gravel LS50,400

3. Typical Section 6.0 meters Wide

a) Earthworks

Formation Volume	= 0.50m[2(6.6m) + 4(0.50m)](1000m)½	= 3800m^3/km
Formation Cost	= 3800m^3/km x LS 3.00/m^3	= LS11,400/km
Side Ditches		= LS 3,600/km
Haulage	= 3800m^3/km x 10km x LS 0.50/m^{3}km	= LS19,000/km
Clearing		= LS 5,400/km
	TOTAL EARTHWORKS COST	LS39,400/km

b) Gravel Surfacing 150mm Thick

Volume	= 0.15m[2(6m) + 4(0.15m)](1000m)½	= 945m^3/km
Gravel Cost	= 945m^3/km x LS 8.00/m^3	= LS 7,560/km
Haulage	= 945m^3/km x (15-1) x LS 0.50/m^{3}km	= LS 6,615/km
	TOTAL GRAVEL COST	LS14,175/km
	USE	LS14,200/km

c) Total Cost Earthworks and Gravel LS53,500/km

4. Comparison

From project cost estimates, earthworks and gravel surfacing accounts for approximately 78 percent of the total costs. Pipe and box culverts, open-bottom culverts, fords and miscellaneous work accounted for the remaining 22 percent. For cost comparisons the preceeding cost estimates were each increased 22 percent.

Roadway Width	Estimated Cost	Percent Increase Over 4m	Percent Increase Over 5.5
4.0m	LS 50,140	0	-
5.5m	LS 61,490	23	0
6.0m	LS 65,150	30	6

Attachment 2

PROJECT IMPLEMENTATION SCHEDULE

Actions	Date	Responsible Entity
1. Preparation of draft scope of work for technical assistance services including the CBD notice requesting pre qualification questionnaires	Jan.1985	USAID
2. PP approved, project authorized	Feb.1985	USAID/GOS
3. Project Agreement signed	Mar.1985	USAID/GOS
4. CBD notice published requesting technical assistance services prequalification questionnaires		
5, RFTP available at AID/W for prequalified firms	April 1985	USAID/AID/GOS
6. Closing date to receive technical proposals for technical assistance services, with proposals received in Khartoum	June 1985	USAID/GOS
7. Selection of first consultant firm for engineering services contract. RBPC negotiates with top firm	July 1985	USAID/GOS
8. RBPC executes technical assistance services contract. USAID approves	July 1985	USAID/GOS
9. T.A. services firm mobilized Khartoum	Sept.1985	GOS/USAID/CONSULTANT
10. Review of Project Program and prepare Inception Report	Sept-Oct 1985	CONSULTANT
11. Begin Road Betterment design, Phase 1	Oct 1985	CONSULTANT
12. Request for prequalification data from Sudanese contractors	Nov.1985	CONSULTANT/GOS/USAID
13. Finalise equipment, material and fuel needs for Kadugli-Dubeibat rehab. work	Nov.1985	CONSULTANT/GOS/USAID
14. Advertise for equipment, materials and fuel for Kadugli-Dubeibat rehab. work	Dec.1985	USAID/AID/GOS

15 Receive prequalification data from Sudanese Contractors	Jan.1986	CONSULTANT/GOS
16. Evaluation of equipment needs of Sudanese Contractors and methods of obtaining and/or financing.	Feb.1986	CONSULTANT/GOS/USAID
17. Order equipment, materials and fuel for Kadugli-Dubeibat rehab. work	Feb.1986	USAID/AID/GOS
18. Evaluation of tendering and contract owned procedures with Sudanese contractors for road betterment work	March 1986	CONSULTANT/GOS/USAID
19. Prepare contract documents for Phase 1	March 1986	CONSULTANT/GOS/AID
20. Prequalified list of Sudanese Contractors approved for Phase 1	March 1986	GOS/USAID
21. Complete road betterment designs for Phase 1	April 1986	CONSULTANT
22. Approval of contract documents and tendering and contract award procedures	May 1986	USAID/GOS/REDSO
23. Phase 1 contract tendering documents furnished to pre qualified Sudanese Contractors	May 1986	USAID/GOS/CONSULTANT
24. Sudanese Contractor's tender documents received	June 1986	GOS/USAID/CONSULTANT
25. Evaluation of Sudanese Contractor's tender documents	July 1986	CONSULTANT/GOS/USAID
26. Competetitive negotiations with Sudanese Contractors	Aug.1986	GOS/USAID/CONSULTANT
27. Award of construction contracts	Aug.1986	GOS/USAID
28. TA Maintenance Engineer and Master Mechanic arrive Dilling RBPC maintenance depot	Aug.1986	CONSULTANT
29. Road maintenance equipment for rehab. of Kadugli-Dubeibat road in place at Dilling	Sept.1986	USAID/AID/GOS
30. Assistance to Sudanese Contractor in obtaining needed equipment, material and fuel	Sept. 1986	USAID/GOS/CONSULTA
31. Sudanese Contractors begin mobilization on site (4 months)	Sept.1986	CONTRACTORS

32. Project accounts audited	Sept.1986	USAID
33. Rehab. of Kadugli-Dubeibat Road begins	Oct.1986	GOS/CONSULTANT
34. Begin Phase 2 program - see Schedule A	Oct.1986	(see schedule A)
35. T.A. services personnel to Phase 1 construction site	Nov.1986	Consultant
36. Construction of Phase 1 begins	Jan 1987	Contractor/Consultant
37. First project evaluation	April 1987	USAID/REDSO/GOS
38. Project accounts audited	Sept.1987	USAID/REDSO/GOS
39. Begin Phase 3 program (see Schedule A)	Oct.1987	(see schedule A)
40. Rehab. of Kadugli-Dubeibat Road completed	May 1988	CONTRACTOR/CONSULTANT
41. Rehab. of Kadugli-Dubeibat Road and equipment maintenance evaluated	June/July 1988	CONSULTANT/GOS
42. Project Accounts audited	Sept.1988	USAID
43. T.A. Maintenance Engineer and Mechanical Engineer transfer to Phase 1 construction. Begin maintenance organization and training assistance (1).	Aug.1988	CONSULTANT/GOS
44. Phase 4 Program begins (see Schedule A)	Oct 1988	(See Schedule A)
45. Complete Phase 1 construction	Dec.1988	CONTRACTOR
46. Inspection and acceptance of Phase 1 construction	Jan.1989	GOS/USAID/CONSULTANT
47. Routine maintenance of Phase 1 begins	Jan.1989	GOS/CONSULTANT
48. Project accounts audited	Sept.1984	USAID
49. Second project evaluation	Oct 1989	USAID/REDSO/GOS

50. Complete Phase 2 construction	Dec.1989	CONTRACTOR
51. Routine Maintenance Phase 2 begins	Jan.1990	GOS/CONSULTANT
52. Project accounts audited	Sept.1990	USAID
53. Complete Phase 3 construction	Dec.1990	CONTRACTOR
54. Routine maintenance Phase 3 begins	Jan 1991	GOS/CONSULTANT
55. Third project evaluation	April 1991	USAID/REDSO/GOS
56. Project accounts audit	Sept. 1991	USAID
57. Complete Phase 4 Construction	Dec. 1991	CONTRACTOR
58. Routine maintenance Phase 4 begins	Jan.1992	GOS/CONSULTANT
59. T.A. services consultant's construction personnel leave the site	Jan 1992	CONSULTANT/USAID
60. Maintenance engineer and Master Mechanic leave the site	March 1992	CONSULTANT/USAID
61. Project accounts audit	March 1992	USAID
62. TA Team Director leaves the project	April 1992	CONSULTANT/USAID

TABLE D

SCHEDULE A
PHASES OF ROAD BETTERMENT

Action	Date	Responsible Entity
1. Begin road betterment designs Phase 2	Oct 1986	Consultant
2. Complete Phase 2 designs and contract documents	Apr.1987	Consultant
3. Phase 2 tendering documents furnished to pre qualified Sudanese contractors		Consultant
4. Sudanese contractor's tender documents received	June 1987	GOS/USAID/consultant
5. Evaluation of Sudanese contractor's tender documents	July 1987	Consultant/GOS/USAID
6. Competative negotiations with Sudanese contractors	Aug. 1987	GOS/USAID/Consultant
7. Award of construction contract	Aug.1987	GOS/USAID
8. Assistance to contractor in obtaining needed equipment, materials and fuels.		Consultant
9. Mobilization of Sudanese Contractors (4 months)	Sept.1987	Contractor
10. Construction of Phase 2 begins	Jan.1988	Contractor/Consultant
11. Construction of Phase 2 completed	Dec.1989	Contractor
12. Inspection and acceptance of Phase 2 construction	Jan.1990	GOS/USAID/Consultant
13. Phase 2 opened to traffic	Jan.1990	GOS
14. Routine maintenance of Phase 2 begins	Jan.1990	GOS/Contractor

NOTE: Schedules for Phase 3 and 4 similar but 1 and 4 years later respectively.

ATTACHMENT 3

Economic Analysis

1. Economic Viability

The roads proposed in this study were analyzed in two previous studies, one by Norconsult[1] and another by Carl Bro.[2] The Norconsult study recommended a series of alignments which connected Balahat (on the proposed Kosti-Umm Ruwaba highway) with Talodi (southeast of Kadugli) passing through Sherbeila, Barid, El Abbasiya, Rashad, Abu Gubeiha, Kologi and Talodi, enroute. This routing was found not to be economically feasible. The referenced Carl Bro study analyzed the segment Kadugli-Talodi, and judged it as feasible.

Since the present study has determined the cited Balahat-Kadugli routing to be economically feasible, although two of the segments (4A: Kologi-Abu Gubeiha and 4B: Shagrabeih-Kologi) had low NPV's, the question might well be raised as to the factors leading to this apparent improvement.

There appear to be four principal factors involved. First, a very low cost road has been proposed, making maximum use of economical stream-crossing structures such as fords or Irish bridges. Second, the delay in opening (from 1985/6 to 1988/89-1992/93) has provided additional time for traffic to develop. Third, while the cost of construction materials has risen on the cost side, there have also been countervailing increases in vehicle generating costs, on the benefit side. Fourth, diverted traffic has been keyed to revised forecasts, especially on the Kosti-El Obeid road.

We pointed out in Section H, very conservative traffic growth rates were used for both freight and passengers. These rates have varied with each area segment. While (as indicated) diverted traffic has been keyed to projected levels in the Kosti-Umm Ruwaba road at the north end of the programed routing, it was tied to Kadugli-El Obeid traffic on the southern end.

It is pointed out that the final result of the diversions of traffic on the Kosti-Umm Ruwaba road will be a net of two effects. First, a certain amount of traffic will be diverted to and from this road at Balahat. Second, there will be additions to the Kosti-El Obeid traffic at Balahat, involving vehicles which currently proceed cross-country to and from Kosti from points in the project area, e.g. Kologi, Abu Gubeiha, Rashad, El Abbasiya and Barid. It can be safely assumed that the access to the paved Kosti-Umm Ruwaba highway which will be provided by the project road should ensure the diversion of a high proportion of this traffic. There should also be some diversion of the current Shagrabeth-Semeih cotton traffic, to the study roads.

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(1) Norconsult, A.S., Sudan Feeder Roads Master Plan, Final Report, May 1984
(2) Carl Bros, A.S., Economic and Technical Study of the Kadugli-Talodi Road, Feb. 1974

In any event, very conservative projections of the levels of this diverted traffic were made. For example, a maximum of 4 percent of annual traffic to and from the Kosti-El Obeid road was allocated to the study segments, decreasing to 2 percent near the southern end of the routing. West of Shagrabeth, diversions were assumed to be towards the Kadugli-El Obeid road, and on the Kadugli-Talodi segment, diversion was restricted to 10 percent of normal traffic. Generated traffic on all segments were limited to 10 percent of normal traffic, with only half of the resulting benefits counted.

2. Agricultural Benefits

No credit was taken for agricultural benefits which might result from the opening of these roads. In the first place, annual agricultural production was one of the inputs considered in estimating the number of vehicles required to handle freight and passenger carriage. Projected increases in agricultural production would therefore already be reflected in VOC benefits. In the second place, residual agricultural benefits are difficult to quantify, and agricultural production per se is influenced by a variety of factors other than improvement in roads. For example, a new hybrid dura promises to increase sorghum production 400 percent in the area served by the project roads. Although part of their increased production will be consumed by the farm families involved, a sizeable proportion should eventually be exported from the area. This increase in agricultural production (and the added road traffic which will result) will obviously be due to factors other than the influence of road improvements.

3. Exchange Rates

During the period of the study, the official exchange rate was revised by the Governor of the Bank of Sudan to US$1.00 = Ls.2.100. At the same time, the going rate at the shops of money changers was around US$1.00 = Ls.2.400. In calculations such as estimation of construction costs, where foreign exchange was a factor, the official rate of (US$1.00 = Ls.2.100) was used as most applicable. All benefits and costs have been expressed in Sudanese pounds in the economic analysis, and there has been no shadow pricing.

4. Economic Indicators

The results of the economic analysis of the nine road segments are shown by Table 3-1. The internal rates of return (IRR) for the segments range from 17.3 percent for Section 4A to 40.2 percent for Section 4D, averaging 29.8 percent for the entire alignment. Using a 15 percent discount rate, net present values (NPV) range from Ls.541,000 for Section 4B (Shagrabeth-Kologi) to Ls.10.8 million for Section 4D (Kadugli-Talodi).

In view of the high NPV indicated for Section 4D (Kadugli-Talodi), a second analysis was carried out, with normal traffic reduced by 25 percent, and with diverted and generated traffic reduced accordingly. Even under these conditions of reduced traffic, the NPV was still Ls.7.4 million.

Table 3-1

ECONOMIC INDICATORS, BY ROAD SEGMENT & TOTAL

No.	Segment	NPV ($Ls.10^6$)	IRR
1A	Shebeila-Balahat	1.493	40.1
1B	Barid-Shebeila	3.447	30.1
1C	El Abbasiya-Barid	1.417	27.6
2C	Rashad-El Abbasiya	2.697	28.0
3A	Abu Gubeiha-Rashad	2.143	17.3
4A	Kalogi-Abu Gubeiha	0.595	21.0
4B	Shagrabeih-Kalogi	0.541	23.1
4C	Talodi-Shagrabeih	1.508	40.2
4D	Kadugli-Talodi	10.841	40.2
-	All Segments	24.682	29.8

ATTACHMENT 4

Table 4-1

ROAD 1A - SHERKEILA - MALAHAT

NET PRESENT VALUE AND BENEFIT/COST RATIO CALCULATION

NUMBER OF YEARS=25 DISCOUNT RATE=15.0 PERCENT

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	529.0	400.0	0.0	0.0	0.0
1990	533.0	232.1	0.0	0.0	0.0
1991	10.0	5.7	407.0	407.0	232.7
1992	10.0	5.0	424.4	424.4	211.0
1993	10.0	4.3	442.5	442.5	191.3
1994	61.0	22.9	461.3	461.3	173.4
1995	10.0	3.3	481.0	481.0	157.2
1996	10.0	2.8	503.0	503.0	143.0
1997	10.0	2.5	526.0	526.0	130.0
1998	10.0	2.1	550.0	550.0	118.2
1999	61.0	11.4	575.2	575.2	107.5
2000	10.0	1.6	601.5	601.5	97.8
2001	10.0	1.4	629.0	629.0	88.9
2002	10.0	1.2	661.7	661.7	81.3
2003	10.0	1.1	696.2	696.2	74.4
2004	61.0	5.7	732.4	732.4	68.1
2005	10.0	0.8	770.5	770.5	62.3
2006	10.0	0.7	810.6	810.6	57.0
2007	10.0	0.6	852.8	852.8	52.1
2008	10.0	0.5	897.2	897.2	47.7
2009	61.0	2.8	943.9	943.9	43.6
2010	10.0	0.4	993.0	993.0	39.9
2011	0.0	0.0	687.0	687.0	24.0
TOT	1286.0	709.1	13646.2	13646.2	2201.3

BENEFIT/COST RATIO= 3.10

NET PRESENT VALUE= 1492.2

ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 $

Table 4-2

ROAD 1A - SHERKEILA - BALAHAT

INTERNAL RATE OF RETURN CALCULATION

NUMBER OF YEARS 25

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	529.0	269.3	0.0	0.0	0.0
1990	353.0	128.2	0.0	0.0	0.0
1991	10.0	2.6	407.0	407.0	105.5
1992	10.0	1.8	424.4	424.4	78.5
1993	10.0	1.3	442.5	442.5	58.4
1994	61.0	5.7	461.3	461.3	43.4
1995	10.0	0.7	481.0	481.0	32.3
1996	10.0	0.5	503.0	503.0	24.1
1997	10.0	0.3	526.0	526.0	18.0
1998	10.0	0.2	550.0	550.0	13.4
1999	61.0	1.1	575.2	575.2	10.0
2000	10.0	0.1	601.5	601.5	7.5
2001	10.0	0.1	629.0	629.0	5.6
2002	10.0	0.1	661.7	661.7	4.2
2003	10.0	0.0	696.2	696.2	3.1
2004	61.0	0.2	732.4	732.4	2.4
2005	10.0	0.0	770.5	770.5	1.8
2006	10.0	0.0	810.6	810.6	1.3
2007	10.0	0.0	852.8	852.8	1.0
2008	10.0	0.0	897.2	897.2	0.7
2009	61.0	0.0	943.9	943.9	0.6
2010	10.0	0.0	993.0	993.0	0.4
2011	0.0	0.0	687.0	687.0	0.2
TOT	1286.0	412.5	13646.2	13646.2	412.5

BENEFIT/COST RATIO= 1.00
NET PRESENT VALUE= 0.0
INTERNAL RATE OF RETURN= 40.1 PERCENT
ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LSGK.

Table 4-3

ROAD 1B - SKERKEILA - MARIN

NET PRESENT VALUE AND BENEFIT/COST RATIO CALCULATION

NUMBER OF YEARS=25 DISCOUNT RATE=15.0 PERCENT

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	2268.0	1714.9	0.0	0.0	0.0
1990	1572.0	1033.6	0.0	0.0	0.0
1991	41.0	23.4	1233.0	1233.0	705.0
1992	41.0	20.4	1305.2	1305.2	648.9
1993	41.0	17.7	1381.6	1381.6	597.3
1994	252.0	94.7	1462.4	1462.4	549.8
1995	41.0	13.4	1548.0	1548.0	506.0
1996	41.0	11.7	1573.7	1573.7	447.9
1997	41.0	10.1	1604.0	1604.0	396.5
1998	41.0	8.8	1632.7	1632.7	350.9
1999	252.0	47.1	1661.9	1661.9	310.6
2000	41.0	6.7	1691.7	1691.7	274.9
2001	41.0	5.8	1722.0	1722.0	243.4
2002	41.0	5.0	1794.9	1794.9	220.6
2003	41.0	4.4	1870.9	1870.9	199.9
2004	252.0	23.4	1950.1	1950.1	181.2
2005	41.0	3.3	2032.7	2032.7	164.3
2006	41.0	2.9	2118.7	2118.7	148.9
2007	41.0	2.5	2208.4	2208.4	134.9
2008	41.0	2.2	2301.9	2301.9	122.3
2009	252.0	11.6	2399.4	2399.4	110.9
2010	41.0	1.6	2501.0	2501.0	100.5
2011	0.0	0.0	2820.0	2820.0	98.5
TOT	5504.0	3065.4	38816.2	38816.2	6513.2

BENEFIT/COST RATIO= 2.12

NET PRESENT VALUE= 3447.8

ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-4

ROAD 1B - SKERKEILA - BARID

INTERNAL RATE OF RETURN CALCULATION

NUMBER OF YEARS=25

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	2269.0	1339.1	0.0	0.0	0.0
1990	1572.0	713.2	0.0	0.0	0.0
1991	41.0	14.3	1233.0	1233.0	429.9
1992	41.0	11.0	1305.2	1305.2	349.6
1993	41.0	8.4	1381.6	1381.6	284.4
1994	252.0	39.9	1462.4	1462.4	231.3
1995	41.0	5.0	1548.0	1548.0	188.1
1996	41.0	3.8	1575.7	1575.7	147.2
1997	41.0	2.9	1604.0	1604.0	115.1
1998	41.0	2.3	1632.7	1632.7	90.0
1999	252.0	10.7	1661.9	1661.9	70.4
2000	41.0	1.3	1691.7	1691.7	55.1
2001	41.0	1.0	1722.0	1722.0	43.1
2002	41.0	0.8	1794.9	1794.9	34.5
2003	41.0	0.6	1870.9	1870.9	27.6
2004	252.0	2.9	1950.1	1950.1	22.1
2005	41.0	0.4	2032.7	2032.7	17.7
2006	41.0	0.3	2118.7	2118.7	14.2
2007	41.0	0.2	2208.4	2208.4	11.4
2008	41.0	0.2	2301.9	2301.9	9.1
2009	252.0	0.8	2399.4	2399.4	7.3
2010	41.0	0.1	2501.0	2501.0	5.8
2011	0.0	0.0	2820.0	2820.0	5.1
TOT	3504.0	2139.1	38816.2	38816.2	2139.1

BENEFIT/COST RATIO= 1.00

NET PRESENT VALUE= 0.0

INTERNAL RATE OF RETURN= 30.1 PERCENT

ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-5

ROAD 1C - EL ABBASIYA - WAKID

NET PRESENT VALUE AND BENEFIT/COST RATIO CALCULATION

NUMBER OF YEARS=25 DISCOUNT RATE=15.0 PERCENT

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	1114.0	842.3	0.0	0.0	0.0
1990	743.0	489.5	0.0	0.0	0.0
1991	19.0	10.9	549.0	549.0	313.9
1992	19.0	9.4	570.2	570.2	283.5
1993	19.0	8.2	592.3	592.3	256.1
1994	116.0	43.6	615.2	615.2	231.3
1995	19.0	6.2	639.0	639.0	208.9
1996	19.0	5.4	662.6	662.6	188.3
1997	19.0	4.7	687.0	687.0	169.8
1998	19.0	4.1	712.3	712.3	153.1
1999	116.0	21.7	738.6	738.6	138.0
2000	19.0	3.1	765.8	765.8	124.5
2001	19.0	2.7	794.0	794.0	112.2
2002	19.0	2.3	836.2	836.2	102.8
2003	19.0	2.0	880.7	880.7	94.1
2004	116.0	10.8	927.6	927.6	86.2
2005	19.0	1.5	976.9	976.9	78.9
2006	19.0	1.3	1028.9	1028.9	72.3
2007	19.0	1.2	1083.7	1083.7	66.2
2008	19.0	1.0	1141.3	1141.3	60.6
2009	116.0	5.4	1202.0	1202.0	55.5
2010	19.0	0.8	1266.0	1266.0	50.9
2011	0.0	0.0	1335.0	1335.0	46.6
TOT	2625.0	1477.2	18004.3	18004.3	2893.8

BENEFIT/COST RATIO= 1.96

NET PRESENT VALUE= 1416.6

ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-6

ROAD 1C - EL ABBASIYA - BARID

INTERNAL RATE OF RETURN CALCULATION

NUMBER OF YEARS=25

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	1114.0	683.7	0.0	0.0	0.0
1990	743.0	357.2	0.0	0.0	0.0
1991	19.0	7.2	549.0	549.0	206.8
1992	19.0	5.6	570.2	570.2	168.3
1993	19.0	4.4	592.3	592.3	136.9
1994	116.0	21.0	615.2	615.2	111.4
1995	19.0	2.7	639.0	639.0	90.6
1996	19.0	2.1	662.6	662.6	73.6
1997	19.0	1.7	687.0	687.0	59.8
1998	19.0	1.3	712.3	712.3	48.6
1999	116.0	6.2	738.6	738.6	39.5
2000	19.0	0.8	765.8	765.8	32.1
2001	19.0	0.6	794.0	794.0	26.0
2002	19.0	0.5	836.2	836.2	21.5
2003	19.0	0.4	880.7	880.7	17.7
2004	116.0	1.8	927.6	927.6	14.6
2005	19.0	0.2	976.9	976.9	12.1
2006	19.0	0.2	1028.9	1028.9	10.0
2007	19.0	0.1	1083.7	1083.7	8.2
2008	19.0	0.1	1141.3	1141.3	6.8
2009	116.0	0.5	1202.0	1202.0	5.6
2010	19.0	0.1	1266.0	1266.0	4.6
2011	0.0	0.0	1335.0	1335.0	3.8
TOT	2625.0	1098.4	18004.3	18004.3	1098.4

BENEFIT/COST RATIO= 1.00

NET PRESENT VALUE= 0.0

INTERNAL RATE OF RETURN= 27.6 PERCENT

ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-7

ROAD 2C - RASHAD - EL ABBASIYA

NET PRESENT VALUE AND BENEFIT/COST RATIO CALCULATION

NUMBER OF YEARS=25 DISCOUNT RATE=15.0 PERCENT

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	2369.0	1791.3	0.0	0.0	0.0
1990	1579.0	1038.2	0.0	0.0	0.0
1991	49.0	28.0	1037.0	1037.0	592.9
1992	49.0	24.4	1097.1	1097.1	545.4
1993	49.0	21.2	1160.6	1160.6	501.8
1994	303.0	113.9	1227.9	1227.9	461.6
1995	49.0	16.0	1299.0	1299.0	424.6
1996	49.0	13.9	1358.4	1358.4	386.2
1997	49.0	12.1	1420.6	1420.6	351.2
1998	49.0	10.5	1485.6	1485.6	319.3
1999	303.0	56.6	1553.6	1553.6	290.4
2000	49.0	8.0	1624.7	1624.7	264.1
2001	49.0	6.9	1699.0	1699.0	240.1
2002	49.0	6.0	1790.1	1790.1	220.0
2003	49.0	5.2	1886.0	1886.0	201.5
2004	303.0	28.2	1987.1	1987.1	184.7
2005	49.0	4.0	2093.6	2093.6	169.2
2006	49.0	3.4	2205.8	2205.8	155.0
2007	49.0	3.0	2324.0	2324.0	142.0
2008	49.0	2.6	2448.5	2448.5	130.1
2009	303.0	14.0	2579.7	2579.7	119.2
2010	49.0	2.0	2718.0	2718.0	109.2
2011	0.0	0.0	2802.0	2802.0	97.9
TOT	5944.0	3209.5	37798.1	37798.1	5906.2

BENEFIT/COST RATIO= 1.84

NET PRESENT VALUE= 2696.7

ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-8

ROAD 2C - RASHAD - EL ABBASIYA

INTERNAL RATE OF RETURN CALCULATION

NUMBER OF YEARS :25

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	2369.0	1491.5	0.0	0.0	0.0
1990	1579.0	788.8	0.0	0.0	0.0
1991	49.0	19.4	1037.0	1037.0	411.1
1992	49.0	15.4	1097.1	1097.1	345.1
1993	49.0	12.2	1160.6	1160.6	289.7
1994	303.0	60.0	1227.9	1227.9	243.2
1995	49.0	7.7	1299.0	1299.0	204.1
1996	49.0	6.1	1358.4	1358.4	169.4
1997	49.0	4.8	1420.6	1420.6	140.6
1998	49.0	3.8	1485.6	1485.6	116.6
1999	303.0	18.9	1553.6	1553.6	96.8
2000	49.0	2.4	1624.7	1624.7	80.3
2001	49.0	1.9	1699.0	1699.0	66.6
2002	49.0	1.5	1790.1	1790.1	55.7
2003	49.0	1.2	1886.0	1886.0	46.6
2004	303.0	5.9	1987.1	1987.1	38.9
2005	49.0	0.8	2093.6	2093.6	32.5
2006	49.0	0.6	2205.8	2205.8	27.2
2007	49.0	0.5	2324.0	2324.0	22.7
2008	49.0	0.4	2448.5	2448.5	19.0
2009	303.0	1.9	2579.7	2579.7	15.9
2010	49.0	0.2	2718.0	2718.0	13.3
2011	0.0	0.0	2802.0	2802.0	10.9
TOT	5944.0	2446.2	37798.1	37798.1	2446.2

BENEFIT/COST RATIO= 1.00
NET PRESENT VALUE= 0.0
INTERNAL RATE OF RETURN= 26.0 PERCENT
ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-9

ROAD 3A - ABU GUBEHIA - RASAAD

NET PRESENT VALUE AND BENEFIT/COST RATIO CALCULATION

NUMBER OF YEARS=27 DISCOUNT RATE=15.0 PERCENT

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0
1991	2011.0	1149.8	0.0	0.0	0.0
1992	1341.0	666.7	0.0	0.0	0.0
1993	46.0	19.9	936.0	936.0	404.7
1994	46.0	17.3	998.3	998.3	375.3
1995	46.0	15.0	1064.7	1064.7	348.0
1996	283.0	80.4	1135.5	1135.5	322.8
1997	46.0	11.4	1211.0	1211.0	299.3
1998	46.0	9.9	1277.9	1277.9	274.7
1999	46.0	8.6	1348.5	1348.5	252.0
2000	46.0	7.5	1423.0	1423.0	231.3
2001	283.0	40.0	1501.5	1501.5	212.2
2002	46.0	5.7	1584.5	1584.5	194.7
2003	46.0	4.9	1672.0	1672.0	178.7
2004	46.0	4.3	1763.4	1763.4	163.9
2005	46.0	3.7	1859.9	1859.9	150.3
2006	283.0	19.9	1961.6	1961.6	137.8
2007	46.0	2.8	2068.9	2068.9	126.4
2008	46.0	2.4	2182.0	2182.0	115.9
2009	46.0	2.1	2301.4	2301.4	106.3
2010	46.0	1.8	2427.2	2427.2	97.5
2011	283.0	9.9	2560.0	2560.0	89.4
2012	46.0	1.4	2700.0	2700.0	82.0
2013	0.0	0.0	2469.0	2469.0	65.2
TOT	5220.0	2085.5	36446.2	36446.2	4228.5

BENEFIT/COST RATIO= 2.03
NET PRESENT VALUE= 2143.1
ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-10

ROAD 3A - ABU GUBEHIA - RASAAD

INTERNAL RATE OF RETURN CALCULATION

NUMBER OF YEARS=27

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0
1991	2011.0	749.4	0.0	0.0	0.0
1992	1341.0	390.4	0.0	0.0	0.0
1993	46.0	10.5	936.0	936.0	212.9
1994	46.0	8.2	998.3	998.3	177.4
1995	46.0	6.4	1064.7	1064.7	147.8
1996	283.0	30.7	1135.5	1135.5	123.2
1997	46.0	3.9	1211.0	1211.0	102.7
1998	46.0	3.0	1277.9	1277.9	84.6
1999	46.0	2.4	1348.5	1348.5	69.8
2000	46.0	1.9	1423.0	1423.0	57.5
2001	283.0	8.9	1501.5	1501.5	47.4
2002	46.0	1.1	1584.5	1584.5	39.1
2003	46.0	0.9	1672.0	1672.0	32.2
2004	46.0	0.7	1763.4	1763.4	26.6
2005	46.0	0.5	1859.9	1859.9	21.9
2006	283.0	2.6	1961.6	1961.6	18.0
2007	46.0	0.3	2068.9	2068.9	14.9
2008	46.0	0.3	2182.0	2182.0	12.3
2009	46.0	0.2	2301.4	2301.4	10.1
2010	46.0	0.2	2427.2	2427.2	8.3
2011	283.0	0.8	2560.0	2560.0	6.9
2012	46.0	0.1	2700.0	2700.0	5.6
2013	0.0	0.0	2469.0	2469.0	4.0
TOT	5220.0	1223.3	36446.2	36446.2	1223.3

BENEFIT/COST RATIO= 1.00
NET PRESENT VALUE= 0.0
INTERNAL RATE OF RETURN= 28.0 PERCENT
ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-11

ROAD 4A - KOLOGI - ABU GUREHIA:

NET PRESENT VALUE AND BENEFIT/COST RATIO CALCULATION

NUMBER OF YEARS=27 DISCOUNT RATE=15.0 PERCENT

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0
1991	3518.0	2011.4	0.0	0.0	0.0
1992	2345.0	1165.9	0.0	0.0	0.0
1993	68.0	29.4	905.0	905.0	391.3
1994	68.0	25.6	959.8	959.8	360.8
1995	68.0	22.2	1018.0	1018.0	332.8
1996	419.0	119.1	1079.6	1079.6	306.9
1997	68.0	16.8	1145.0	1145.0	283.0
1998	68.0	14.6	1220.4	1220.4	262.3
1999	68.0	12.7	1300.8	1300.8	243.1
2000	68.0	11.1	1386.5	1386.5	225.3
2001	419.0	59.2	1477.9	1477.9	208.9
2002	68.0	8.4	1575.2	1575.2	193.6
2003	68.0	7.3	1679.0	1679.0	179.4
2004	68.0	6.3	1768.5	1768.5	164.3
2005	68.0	5.5	1862.9	1862.9	150.5
2006	419.0	29.4	1962.2	1962.2	137.9
2007	68.0	4.2	2066.9	2066.9	126.3
2008	68.0	3.6	2177.1	2177.1	115.7
2009	68.0	3.1	2293.2	2293.2	105.9
2010	68.0	2.7	2415.5	2415.5	97.0
2011	419.0	14.6	2544.3	2544.3	88.9
2012	68.0	2.1	2680.0	2680.0	81.4
2013	0.0	0.0	4357.0	4357.0	115.1
TOT	8627.0	3575.2	37874.8	37874.8	4170.5

BENEFIT/COST RATIO= 1.17
NET PRESENT VALUE= 595.3
ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-12

ROAD 4A - KULOGI - ABU GUBEHIA

INTERNAL RATE OF RETURN CALCULATION

NUMBER OF YEARS=27

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0
1991	3518.0	1859.1	0.0	0.0	0.0
1992	2345.0	1056.6	0.0	0.0	0.0
1993	68.0	26.1	905.0	905.0	347.7
1994	68.0	22.3	959.8	959.8	314.4
1995	68.0	19.0	1018.0	1018.0	284.3
1996	419.0	99.8	1079.6	1079.6	257.1
1997	68.0	13.8	1145.0	1145.0	232.5
1998	68.0	11.8	1220.4	1220.4	211.3
1999	68.0	10.0	1300.8	1300.8	192.0
2000	68.0	8.6	1386.5	1386.5	174.5
2001	419.0	45.0	1477.9	1477.9	158.6
2002	68.0	6.2	1575.2	1575.2	144.1
2003	68.0	5.3	1679.0	1679.0	130.9
2004	68.0	4.5	1768.5	1768.5	117.6
2005	68.0	3.9	1862.9	1862.9	105.6
2006	419.0	20.3	1962.2	1962.2	94.9
2007	68.0	2.8	2066.9	2066.9	85.2
2008	68.0	2.4	2177.1	2177.1	76.5
2009	68.0	2.0	2293.2	2293.2	68.7
2010	68.0	1.7	2415.5	2415.5	61.7
2011	419.0	9.1	2544.3	2544.3	55.4
2012	68.0	1.3	2680.0	2680.0	49.8
2013	0.0	0.0	4337.0	4337.0	69.0
TOT	8627.0	3231.5	37874.8	37874.8	3231.5

BENEFIT/COST RATIO= 1.00
NET PRESENT VALUE= 0.0
INTERNAL RATE OF RETURN= 17.3 PERCENT
ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-13

ROAD 4B - SHAGKABETH - KOLOGI:

NET PRESENT VALUE AND BENEFIT/COST RATIO CALCULATION

NUMBER OF YEARS=26 DISCOUNT RATE=15.0 PERCENT

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0
1990	1069.0	702.9	0.0	0.0	0.0
1991	713.0	407.7	0.0	0.0	0.0
1992	22.0	10.9	335.0	335.0	166.6
1993	22.0	9.5	369.0	369.0	159.5
1994	22.0	8.3	406.4	406.4	152.8
1995	136.0	44.5	447.6	447.6	146.3
1996	22.0	6.3	493.0	493.0	140.1
1997	22.0	5.4	508.1	508.1	125.6
1998	22.0	4.7	523.7	523.7	112.6
1999	22.0	4.1	539.8	539.8	100.9
2000	136.0	22.1	556.3	556.3	90.4
2001	22.0	3.1	573.4	573.4	81.0
2002	22.0	2.7	591.0	591.0	72.6
2003	22.0	2.4	615.9	615.9	65.8
2004	22.0	2.0	641.9	641.9	59.6
2005	136.0	11.0	668.9	668.9	54.1
2006	22.0	1.5	697.1	697.1	49.0
2007	22.0	1.3	726.5	726.5	44.4
2008	22.0	1.2	757.2	757.2	40.2
2009	22.0	1.0	789.1	789.1	36.5
2010	136.0	5.5	822.3	822.3	33.0
2011	22.0	0.8	857.0	857.0	29.9
2012	22.0	0.7	1284.0	1284.0	39.0
TOT	2700.0	1259.5	13203.3	13203.3	1800.0

BENEFIT/COST RATIO= 1.43
NET PRESENT VALUE: 540.5
ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-14

ROAD 48 - SHAGRABETH - KOLOGI

INTERNAL RATE OF RETURN CALCULATION

NUMBER OF YEARS=26

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0
1990	1069.0	604.0	0.0	0.0	0.0
1991	713.0	333.1	0.0	0.0	0.0
1992	22.0	8.5	335.0	335.0	129.4
1993	22.0	7.0	369.0	369.0	117.8
1994	22.0	5.8	406.4	406.4	107.3
1995	136.0	29.7	447.6	447.6	97.7
1996	22.0	4.0	493.0	493.0	88.9
1997	22.0	3.3	508.1	508.1	75.8
1998	22.0	2.7	523.7	523.7	64.6
1999	22.0	2.2	539.8	539.8	55.0
2000	136.0	11.5	556.3	556.3	46.9
2001	22.0	1.5	573.4	573.4	40.0
2002	22.0	1.3	591.0	591.0	34.0
2003	22.0	1.0	615.9	615.9	29.3
2004	22.0	0.9	641.9	641.9	25.3
2005	136.0	4.4	668.9	668.9	21.8
2006	22.0	0.6	697.1	697.1	18.8
2007	22.0	0.5	726.5	726.5	16.2
2008	22.0	0.4	757.2	757.2	13.9
2009	22.0	0.3	789.1	789.1	12.0
2010	136.0	1.7	822.3	822.3	10.3
2011	22.0	0.2	857.0	857.0	8.9
2012	22.0	0.2	1284.0	1284.0	11.0
TOT	2700.0	1024.9	13203.3	13203.3	1024.9

BENEFIT/COST RATIO= 1.00
NET PRESENT VALUE= 0.0
INTERNAL RATE OF RETURN= 21.0 PERCENT
ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-15

ROAD 4C - TALOOI - SHAGRABETH

NET PRESENT VALUE AND BENEFIT/COST RATIO CALCULATION

NUMBER OF YEARS 26 DISCOUNT RATE 15.0 PERCENT

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0
1990	2097.0	1378.8	0.0	0.0	0.0
1991	1398.0	799.3	0.0	0.0	0.0
1992	43.0	21.4	778.0	778.0	386.8
1993	43.0	18.6	827.6	827.6	357.8
1994	43.0	16.2	880.3	880.3	330.9
1995	267.0	87.3	936.4	936.4	306.1
1996	43.0	12.2	996.0	996.0	283.1
1997	43.0	10.6	1044.9	1044.9	258.3
1998	43.0	9.2	1096.2	1096.2	235.6
1999	43.0	8.0	1150.1	1150.1	215.0
2000	267.0	43.4	1206.6	1206.6	196.1
2001	43.0	6.1	1265.8	1265.8	178.9
2002	43.0	5.3	1328.0	1328.0	163.2
2003	43.0	4.6	1392.0	1392.0	148.8
2004	43.0	4.0	1459.2	1459.2	135.6
2005	267.0	21.6	1529.5	1529.5	123.6
2006	43.0	3.0	1603.3	1603.3	112.7
2007	43.0	2.6	1680.6	1680.6	102.7
2008	43.0	2.3	1761.7	1761.7	93.6
2009	43.0	2.0	1846.6	1846.6	85.3
2010	267.0	10.7	1935.7	1935.7	77.8
2011	43.0	1.5	2029.0	2029.0	70.9
2012	43.0	1.3	3810.0	3810.0	115.7
TOT	5294.0	2470.0	30557.4	30557.4	3978.4

BENEFIT/COST RATIO= 1.61
NET PRESENT VALUE= 1508.4
ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-16

ROAD 4C - TALODI - SHAGRABETH

INTERNAL RATE OF RETURN CALCULATION

NUMBER OF YEARS=26

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0
1990	2097.0	1125.1	0.0	0.0	0.0
1991	1378.0	609.5	0.0	0.0	0.0
1992	43.0	15.2	778.0	778.0	275.6
1993	43.0	12.4	827.6	827.6	238.2
1994	43.0	10.1	880.3	880.3	205.9
1995	267.0	50.7	936.4	936.4	178.0
1996	43.0	6.6	996.0	996.0	153.8
1997	43.0	5.4	1044.9	1044.9	131.1
1998	43.0	4.4	1096.2	1096.2	111.8
1999	43.0	3.6	1150.1	1150.1	95.3
2000	267.0	18.0	1206.6	1206.6	81.2
2001	43.0	2.4	1265.8	1265.8	69.3
2002	43.0	1.9	1328.0	1328.0	59.0
2003	43.0	1.6	1392.0	1392.0	50.3
2004	43.0	1.3	1459.2	1459.2	42.8
2005	267.0	6.4	1529.5	1529.5	36.5
2006	43.0	0.8	1603.3	1603.3	31.1
2007	43.0	0.7	1680.6	1680.6	26.5
2008	43.0	0.6	1761.7	1761.7	22.5
2009	43.0	0.4	1846.6	1846.6	19.2
2010	267.0	2.3	1935.7	1935.7	16.4
2011	43.0	0.3	2029.0	2029.0	13.9
2012	43.0	0.2	3810.0	3810.0	21.3
TOT	5294.0	1879.7	30557.4	30557.4	1879.7

BENEFIT/COST RATIO= 1.00

NET PRESENT VALUE= 0.0

INTERNAL RATE OF RETURN= 23.1 PERCENT

ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-17

ROAD 4D - KADUGLI - TALODI

NET PRESENT VALUE AND BENEFIT/COST RATIO CALCULATION

NUMBER OF YEARS=24 DISCOUNT RATE=15.0 PERCENT

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	3573.0	3107.0	0.0	0.0	0.0
1989	2382.0	1801.1	0.0	0.0	0.0
1990	75.0	49.3	2854.0	2854.0	1876.6
1991	75.0	42.9	2946.8	2946.8	1684.8
1992	75.0	37.3	3042.6	3042.6	1512.7
1993	462.0	199.7	3141.5	3141.5	1358.1
1994	75.0	28.2	3243.6	3243.6	1219.4
1995	75.0	24.5	3349.0	3349.0	1094.8
1996	75.0	21.3	3457.9	3457.9	982.9
1997	75.0	18.5	3570.3	3570.3	882.5
1998	462.0	99.3	3686.3	3686.3	792.4
1999	75.0	14.0	3806.2	3806.2	711.4
2000	75.0	12.2	3929.9	3929.9	638.7
2001	75.0	10.6	4057.6	4057.6	573.5
2002	75.0	9.2	4189.5	4189.5	514.9
2003	462.0	49.4	4325.7	4325.7	462.3
2004	75.0	7.0	4466.3	4466.3	415.0
2005	75.0	6.1	4611.5	4611.5	372.6
2006	75.0	5.3	4761.4	4761.4	334.6
2007	75.0	4.6	4916.2	4916.2	300.4
2008	462.0	24.5	5076.0	5076.0	269.7
2009	75.0	3.5	5241.0	5241.0	242.1
2010	0.0	0.0	4412.0	4412.0	177.3
TOT	9003.0	5575.5	83085.2	83085.2	16416.6

BENEFIT/COST RATIO= 2.94
NET PRESENT VALUE= 10841.2
ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1985 LS

Table 4-18

ROAD 4D - KABUGLI - TALOOI

INTERNAL RATE OF RETURN CALCULATION

NUMBER OF YEARS=24

YEAR	COSTS	PRESENT VALUE	TOTAL BENEFITS	TOTAL BENEFITS	PRESENT VALUE
1987	0.0	0.0	0.0	0.0	0.0
1988	3573.0	2547.7	0.0	0.0	0.0
1989	2382.0	1211.1	0.0	0.0	0.0
1990	75.0	27.2	2854.0	2854.0	1034.7
1991	75.0	19.4	2946.8	2946.8	761.7
1992	75.0	13.8	3042.6	3042.6	560.8
1993	462.0	60.7	3141.5	3141.5	412.9
1994	75.0	7.0	3243.6	3243.6	304.0
1995	75.0	5.0	3349.0	3349.0	223.8
1996	75.0	3.6	3457.9	3457.9	164.8
1997	75.0	2.5	3570.3	3570.3	121.3
1998	462.0	11.2	3686.3	3686.3	89.3
1999	75.0	1.3	3806.2	3806.2	65.7
2000	75.0	0.9	3929.9	3929.9	48.4
2001	75.0	0.7	4057.6	4057.6	35.6
2002	75.0	0.5	4189.5	4189.5	26.2
2003	462.0	2.1	4325.7	4325.7	19.3
2004	75.0	0.2	4466.3	4466.3	14.2
2005	75.0	0.2	4611.5	4611.5	10.5
2006	75.0	0.1	4761.4	4761.4	7.7
2007	75.0	0.1	4916.2	4916.2	5.7
2008	462.0	0.4	5076.0	5076.0	4.2
2009	75.0	0.0	5241.0	5241.0	3.1
2010	0.0	0.0	4412.0	4412.0	1.8
TOT	9003.0	3915.7	83085.2	83085.2	3915.7

BENEFIT/COST RATIO= 1.00
NET PRESENT VALUE= 0.0
INTERNAL RATE OF RETURN= 40.2 PERCENT
ALL COSTS AND BENEFITS IN THOUSANDS OF CONSTANT 1983 LS